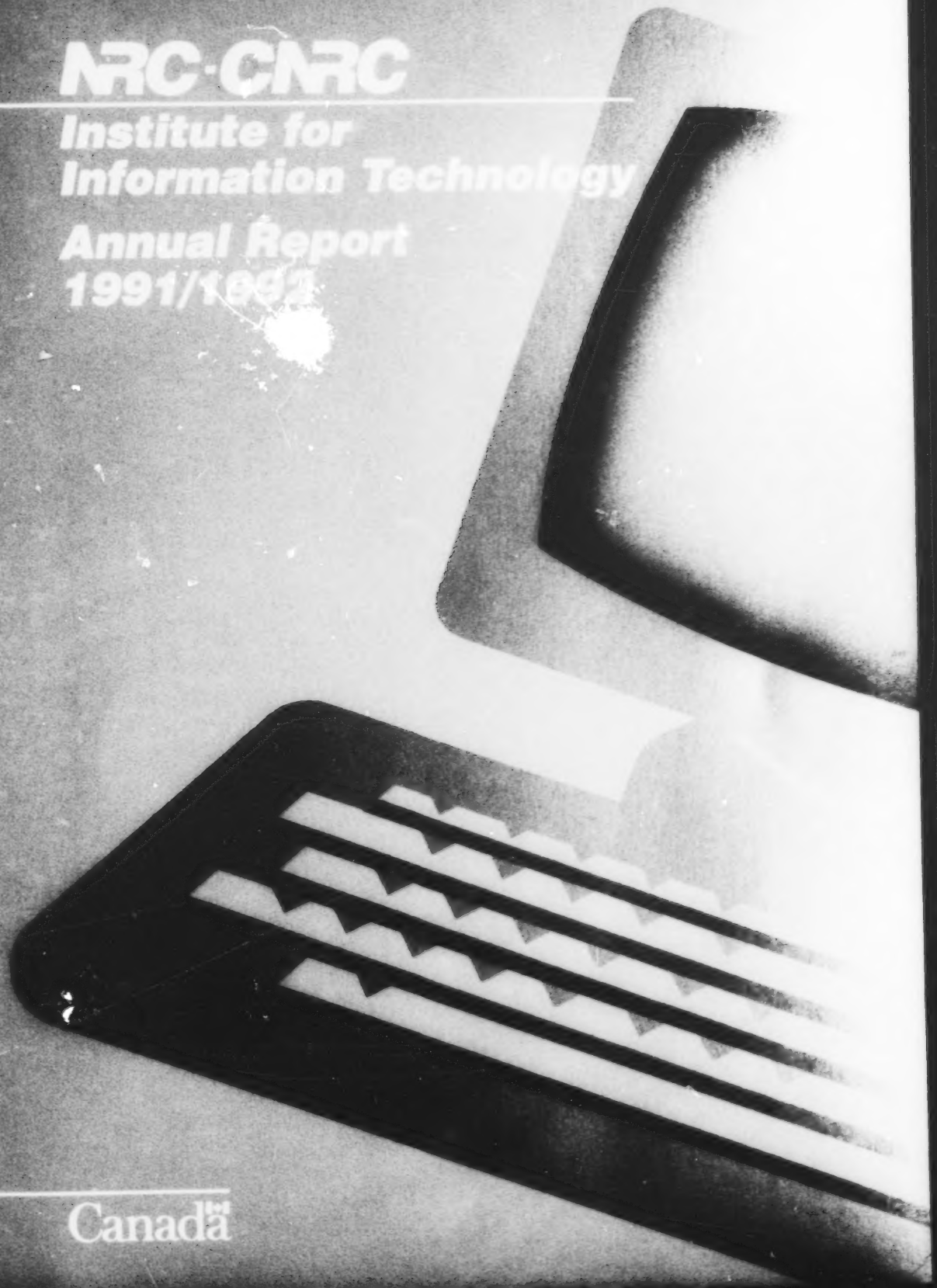
National Research Council Canada
Conseil national de recherches Canada

ISSN 1183-0222

NRC·CNRC

Institute for Information Technology

Annual Report 1991/1992



Canada

Annual Report of the Institute for Information Technology

1991/1992

93-01222/

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NRC 35023

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Institute for Information Technology
Room 301, A.G.L. McNaughton Building (M-50)
National Research Council of Canada
Ottawa, Ontario, Canada
K1A 0R6

Disponible en français

September 1992

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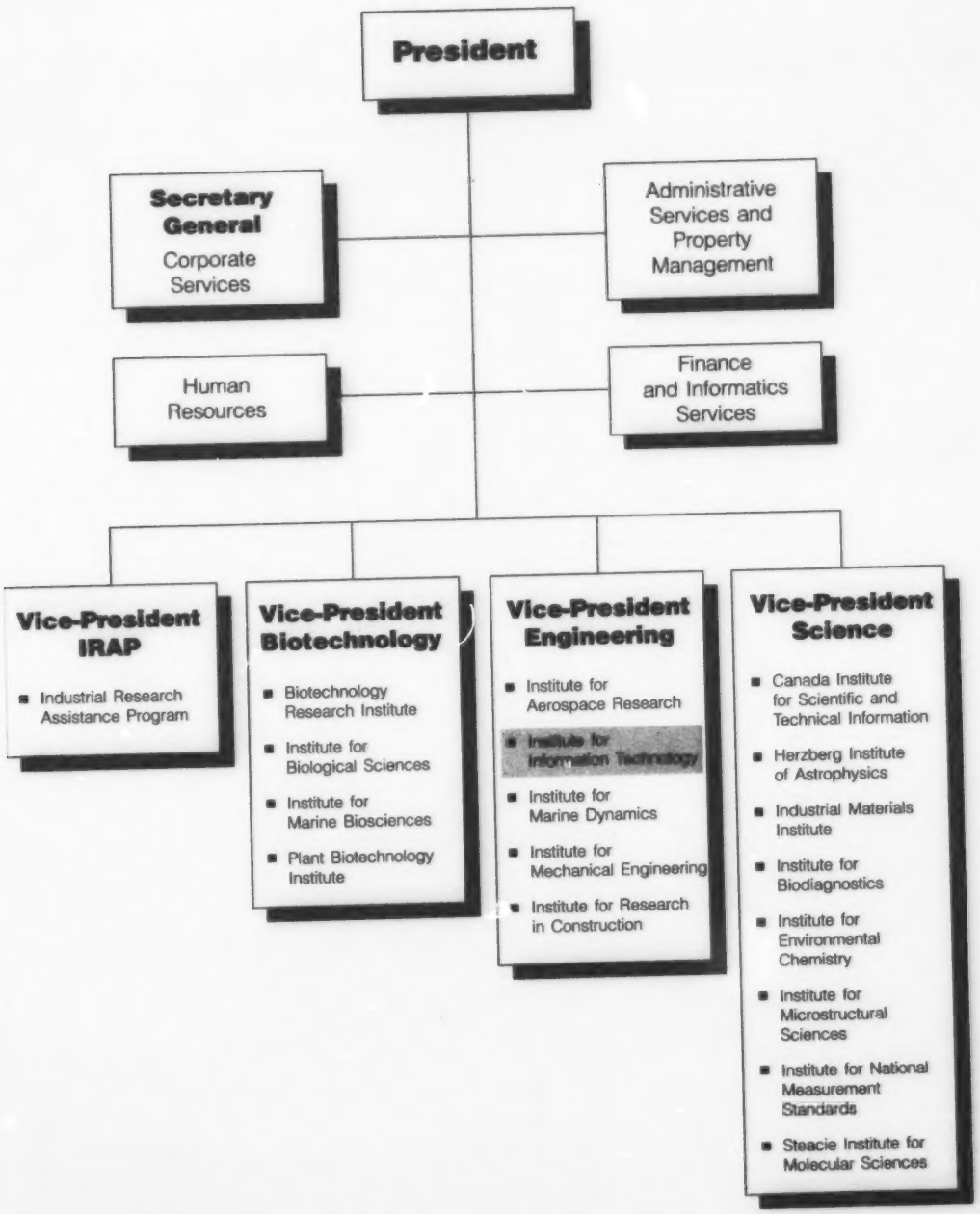
National Research Council Canada



1. Vice-President's Message

Challenge and change. These are the watchwords of the nineties as Canadian companies strive to compete in the global marketplace.

Technology, the product of research and development programs, underpins industrial competitiveness. Therein lies our greatest challenge — to bring about advances in engineering, science, and technology that will help sustain the prosperity of Canada.

The National Research Council is committed to collaborating with Canadian companies to achieve the technological advantage to compete and to succeed in the 1990s and beyond, as defined in the Long Range Plan.

The five institutes that form the Engineering Sector play a vital role to bring about the changes necessary throughout our society.

The Engineering Sector serves Canada by promoting, practicing, transferring, and disseminating engineering research, utilizing its unique facilities and expertise to improve the well-being of Canadians and enhance Canada's industrial competitive advantage.

This year, the Engineering Sector faced some changes. The Industrial Research Assistance Program was separated from the Sector, and Dr. Clifford Baronet, Vice-President of Engineering and Technology, was asked to assume executive and operational responsibility for the program as Vice-President IRAP. I became Vice-President Engineering as of March 1, 1992.

A strategic assessment of NRC's five engineering institutes and three programs was initiated early in 1992. As a rigorous evaluation of NRC engineering R&D work and its impact, the study is helping to identify upcoming technological needs and opportunities in Canadian industry.

I wish to express my appreciation to Dr. Baronet for moving the Engineering Sector in this direction and for his contribution in defining the framework of the assessment.

The findings of this comprehensive assessment study will help us align our research efforts to respond effectively to Canada's needs, especially in areas of wealth creation, the infrastructure, and the public good. This may well lead to some restructuring; we will face this challenge in the year to come.

In 1991, Institute Advisory Boards were established to involve the client community in our on-going strategic planning. The Advisory Boards, which have seen their first full year of operation, provide each institute with a window on the needs of its clients -- and also provide the clients with a better appreciation of institute capabilities and resources. Thus the Advisory Boards, which are appointed by Council, help ensure that our research activities continue to be relevant to national needs and goals.

Other changes in the organization of the Sector occurred early in 1992. NRC's governing Council confirmed the establishment of the Institute for Biodiagnostics and the closure of the Canadian Institute for Industrial Technology in Winnipeg (CIIT). This resulted in a 3% decrease of the resources of the Engineering Sector.

Council also endorsed a proposal to establish an institute aimed at machinery research, in Vancouver. The personnel and financial resources of the Systems Laboratory (Institute for Information Technology) in Vancouver were transferred to the Institute for Mechanical Engineering as an interim measure, pending further development of the proposal for a new institute.

Enhancing the impact of our R&D work remains a primary concern and one of the most visible aspects of NRC's Long Range Plan. As outlined in the Sector's plans and priorities for 1991–92, we sought to increase our knowledge of the marketplace, strengthen our market orientation, and increase the awareness of NRC held by existing and potential clients. Senior management, for example, conducted more than twenty executive briefings, which led to several new collaborative agreements.

In total, forty-three new collaborative projects were signed and started in 1991–92.

In NRC's 75th Anniversary year, the many contributions of our staff members to the various special events were much appreciated. In particular, the Engineering Open House in October 1991 provided clients, stakeholders, colleagues, and the public excellent insight into the Sector's activities and the extent of our partnerships in research.

Income for the Sector has remained strong. In 1991–92, we reached 96% of our income target of $22M. Preliminary figures indicate that service revenue has decreased by about 10%. However, expenditures by our partners for work done by the Sector in joint research have increased. Royalties from licences have increased about 30%.

The Directors General and I have agreed that, in the coming year, our highest priority is to become more client-oriented. This means creating a "service culture" to improve the linkages between our R&D efforts and the needs of our many clients. It also means making our expertise and facilities more accessible to our clients. We know from recent studies that our clients already value the combination of advanced facilities and research expertise that we provide. We want to expand the number of new clients using more effective technology transfer mechanisms, as well as deepen our relationships with existing clients.

In the meantime, we will continue to recognize and focus on "high leverage" opportunities; that is, opportunities for working with others, in projects where we can make a vital contribution.

This year will see the strengthening of the Engineering Sector Office. The Office will help coordinate affairs such as strategic planning, administrative and financial support, personnel services, and Sector communications. In addition, the Sector Office will continue to coordinate NRC programs in transportation, resources, and security.

Working together, we will maintain a program of world-class R&D. Engineering research and the development of technologies that pay dividends for Canada is our principal raison d'être. We must ensure that our partners in the private sector and elsewhere have access to the technologies resulting from our research activities and that they are able to use such technologies to Canada's competitive advantage. Only then will we have accomplished our goal.

More than ever, Canada needs the National Research Council. And, more than ever, the Council will rely on the talents of its employees. I look forward to working with all of you, as we meet the challenges of the future.

Joe Ploeg
Vice-President (Engineering)

2. Director General's Foreword

S.A. Mayman, Director General

This is the second Annual Report of the Institute for Information Technology. Although still young, the Institute has made significant progress towards fulfilling in a quantifiable manner the goals it has set for itself through its statement of mission and objectives.

2.1 Mission

The Institute for Information Technology (IIT) is committed to supporting the mission of the National Research Council in serving the needs of Canadians by helping to maintain and enhance the economic and social well-being of the country.

The mission of IIT is to assist industry across Canada to achieve excellence in information technology software and systems by promoting, supporting, and undertaking focused, industry-oriented research and development programs in these areas.

To achieve this mission, IIT works in collaboration with industrial, educational, and governmental organizations to accomplish the following strategic objectives:

- to be a national center of knowledge and expertise that will assist industry in the application of advanced information technology
- to perform research and development and to encourage utilization of its technologies by collaborators and clients
- to promote and facilitate the use of advanced information technology in Canada

2.2 Highlights

The ongoing commitment of the Canadian IT sector to significant investment in research and development provides IIT with remarkable opportunities for collaboration. The Institute has worked to elicit from Canadian companies a clear statement of their needs, and has shaped its programs to respond to those needs. IIT's focus on key technologies has permitted it to develop an enviable record for responsiveness. Collaborators already include the "Who's Who" of private sector research investment — IBM, Bell-Northern Research, Northern Telecom, Digital Equipment of Canada Limited (DEC), Canadian Marconi Company, AGT Ltd., Ontario Hydro, Spar Aerospace Limited, General Electric Canada, Telesat Canada, SNC Inc., Thomson-CSF Systems of Canada, MPB Technologies Inc., Forest Engineering Research Institute of Canada (FERIC), PAPRICAN, PRECARN (PRECompetitive Applied Research Network) — as well as a host of smaller companies. During the past year IIT invested more than half of its scientific effort in collaborative projects — an increase from one-third in 1990–91. Direct contributions by partners to these projects exceeded $5M. Projects with other companies are already defined and awaiting availability of resources.

Two new program areas have drawn special interest from potential collaborators — software engineering and photonic systems. The first was identified in the discussions leading up to the formation of IIT, and a laboratory dedicated to this topic has been established. The second has

blossomed as a result of ongoing world-class applied research by the NRC staff involved. A consortium is being established which will bring together 30–40 full-time equivalent staff from NRC, companies, universities, and other research groups to work in the area of optical computing directed specifically at pattern recognition in real time.

Other activities within the Institute continue to attract strong outside support. IIT's exceptional three-dimensional vision technology serves as a base for collaboration in areas ranging from robotics in space to production of dental prostheses. An alliance of five companies has been established to explore applications of the IIT expert system for diagnosis of jet engine faults. Object-oriented programming and symbiotic systems techniques are being used by Transport Canada and its contractors to create state-of-the-art airport planning models.

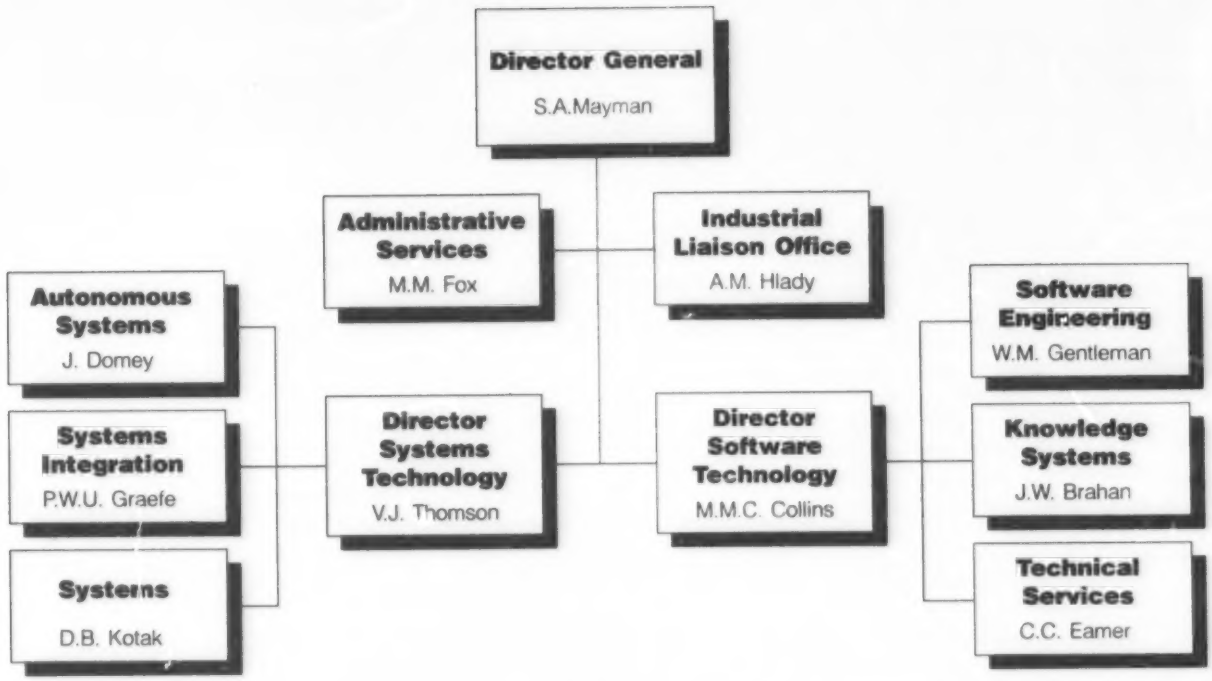
Human resources are the key to IIT's success. The Institute has no major facilities, and therefore relies exclusively on the reputation of its staff and its technology to attract clients and collaborators. In 1991–92 our 3-D vision sensor won the first prize award for new media technology at Production 91. Three staff members were awarded first prize in the Competition on the Practice of Operational Research at the Canadian Operational Research Society's annual conference. Five staff members were honored by being selected to receive NRC Merit Awards. IIT staff serve as adjunct professors at three universities, and contribute regularly to professional activities through organization and participation in national and international conferences, societies, and standards organizations.

2.3 Priorities

The Institute will, in the coming year, build on its collaborative activities in areas which are consistent with its mandate and appropriate to its capabilities. High priority will be given to fulfilment of commitments in the areas of software engineering and photonics. The robotics and systems integration activities will focus on areas of significant industrial interest. The critical measure of success will be significant growth in the level of industrial contribution to IIT programs.

S.A. Mayman
Director General

3. Institute for Information Technology



The Institute for Information Technology is one of NRC's five Engineering Institutes. In 1991–1992, there were five laboratories within IIT, four on NRC's Montreal Road campus in Ottawa and one adjacent to the University of British Columbia in Vancouver.

There are four elements to the Institute's research program: software engineering and knowledge-based systems as part of software technology; sensor-based automation and systems integration as part of systems technology. An outline of the program is given in the table below.

In Ottawa, one laboratory was responsible for each research element. In Vancouver, the Systems Laboratory focused on systems integration, with particular emphasis on the needs of the resource industries.

IIT research program

Software Technology		Systems Technology	
Software Engineering	Knowledge-based Systems	Sensor-based Automation	Systems integration
Realtime and embedded systems	Intelligent advisor systems	Sensor-based robotics	Manufacturing support systems
Large-scale systems	Diagnostic systems	Sensor systems	Resource industry support systems
Commercial software products	Machine learning	Photonic systems	Electromagnetic protection

4. Institute Activities

4.1 Goals and Achievements

The Institute for Information Technology's goals are

- To be a national center of knowledge and expertise that will assist industry in the application of advanced information technology
- To perform research and development and to encourage utilization of its research facilities by collaborators and clients
- To promote and facilitate the use of advanced information technology in Canada

The IIT research program is strongly influenced by the expressed needs of industry, especially the IT sector. The Institute has identified the interest and participation in its research program by Canadian companies as an important measure of its relevance. Currently more than 50% of IIT research staff are involved in joint research projects with companies across Canada through a variety of arrangements. These range from one-on-one exchanges with respect to a specific topic to participation in large research consortia. In many instances collaborators share IIT facilities — there were 42 guest workers at the Institute in the past year — but in some cases IIT staff work at the premises of the industrial partners. Technical expertise is also transferred by IIT researchers acting as scientific advisors to contractors undertaking advanced technology or research projects for federal government departments such as the Canadian Space Agency (CSA) and the Department of National Defence (DND). Six researchers acted as scientific advisors for the CSA Strategic Technologies for Automation and Robotics (STEAR) program and two were advisors for DND's Canadian Towed Array Sonar System (CANTASS) program. The list of participants in joint R&D projects includes 25 organizations (16 companies), with another 15 at various stages of negotiation. IIT staff are also active in both national and international Standards Organizations.

The list of participants in joint R&D projects includes 25 organizations ...

IIT leverages its limited staff resources through technical participation in research groups with industry. SIMCON (Software for Integrated Manufacturing Consortium) has begun work on two consortium-defined projects and consortium members are working on these projects in cooperation with IIT staff at IIT. An alliance of five companies has just completed a feasibility study and will submit a proposal to Industry, Science and Technology Canada for funding support to extend and commercialize IIT's work in engine health monitoring (EHM). OPCOM (Optical Processing and Computing Consortium of Canada) now has the commitment of five companies and both administrative and technical organization is well advanced. In addition to these IIT initiatives, IIT's mobile robot project has become a key element of the PRECARN Autonomous Robot in a Known environment project (ARK) and IIT is participating as a subcontractor to SNC Inc. in the PROGERT consortium to provide data management and integration for the Forestry Sector.

4.2 Summary of Research Programs and Activities

Autonomous Systems Laboratory

Photonic Systems

Photonic Systems is the fastest growing activity within IIT, responding to industry's recognition of this technology as the opportunity for the next major advance in IT. The objective is the development of high-speed signal/image processing systems and sensor systems involving a combination of optical and electronic technology. The Optically Enhanced Computing effort at IIT and with associated partners has continued to grow. During 1991–92 thirteen Guest Workers joined eight NRC staff to work in this area. With the assistance of the Ottawa Carleton Research Institute (OCRI), the organization of OPCOM, the Optical Processing and Computing Consortium of Canada, has made significant progress. Five companies (DEC, Hughes-Leitz, Canadian Marconi Company, Iotek Inc., and Andrew Engineering Ltd.) are

now preparing a formal joint funding request to ISTC. IIT hosted a seminar on "Optically Enhanced Computing" attended by over 80 people from across Canada. Realtime correlation was demonstrated in the laboratory and a system using computer-generated holograms (CGH) for clock distribution, developed for DEC, has been fabricated and is being tested.

Development of Q-switched fiber lasers has now advanced to the point of commercialization. A collaborative project has been negotiated with MPB Technologies for its continued development and application to optical fiber networks. The prototype of the Q-switched fiber laser was presented at the International Conference on Lasers and Electro-Optics (CLEO) 1991. It attracted significant attention as it achieved the highest power yet for this type of laser (350 W peak). A photograph of the laser was featured on the cover of the journal *Applied Optics*.

The immense industrial potential of 3-D vision was demonstrated ...

Sensor Systems

The Institute continued its world-class research activity in 3-D vision. The present activities are based upon the unique 3-D vision sensor technologies developed at NRC — aimed at machine vision systems for guidance, robot control, and dimensional measurement and inspection.

Through extensive collaboration with partners from industry, university, and government, the laser scanning technology is being adapted to a variety of applications. IIT's 3-D Color Technology received the first prize award for new media technology at Production 91 in Montreal. The fast search and track strategy with the random access laser scanner using a cooperative target has been achieved in the laboratory and scanner conversion to the use of an eye-safe laser is progressing. In cooperation with Telesat Canada, 3-D color images were transmitted via satellite. IIT technology makes satellite transmission economically feasible by providing a very efficient description of the object. The immense industrial potential of 3-D vision was demonstrated by using 3-D data acquired with the laser scanning camera to reproduce physical models of objects using stereolithography and laser sintering. A small internal effort in the conversion of 3-D data to a CAD description is continuing with one industrial partner, and the effort to interest additional suitable partners is being intensified.

Sensor-Based Robotics

The sensor-based robotics subprogram is developing and demonstrating sensor-based robotic systems for use in unstructured environments. The two current research topics are advanced manipulator

3-D scan of the Space Shuttle Mission specialists. (STS-52). Left, intensity data; right, 3-D data coded in grey levels.

3-D laser scanner mounted on robot wrist allows robot to locate, identify, and track objects in its environment.

systems and self-navigating vehicles. In both areas the capability of laboratory developments is being extended in co-operation with industrial partners. In the first year of a 2-year collaboration, elements of the supervisory control project and the object-oriented control architecture have been transferred to the STEAR Request for Proposal #3 contractors, International Submarine Engineering Ltd. and Thomson-CSF Systems of Canada. The IIT mobile robot project, EAVE, has been formally recognized as a critical element of the PRECARN ARK project. This year untethered point-to-point collision-free operation of the mobile robot vehicle using the ultrasound sensors and the reflexive collision avoidance algorithms was achieved.

Knowledge Systems Laboratory

The Knowledge Systems program is creating and refining tools in the field of applied AI technology through collaborative projects with industry. Three areas are being targeted, advisor systems, diagnostic systems, and machine learning. During the year, a number of technical improvements were made to the database advisor. Advisor technology is being applied to the EMI/EMC advisor HardSys/HardDraw and work has begun on an advisor system for siting antennas (TACAN). Both projects are in cooperation with DND. The successful demonstration of the engine health monitoring (EHM) diagnostic techniques has convinced five companies (GE Aircraft Engines, Information Fusion Systems Corporation, Canadian Marconi, Thomson-CSF, and MDS Aero Support Corp.) to form an alliance to extend and commercialize this software. Discussions with interested companies have also begun to extend the diagnostic systems technology to other application areas. Machine learning techniques have been applied to the engine diagnostics project and, as embodied in the Intelligent MAnufacturing FOreman (IMAFO), they have been successfully evaluated in a process optimization task for electrochemical milling at the General Electric Aircraft Engines Canada Bromont plant.

Software Engineering Laboratory

The program is developing tools and techniques applicable to the process of creating and supporting software from project initiation through delivery, maintenance, and evolution. There is great demand for collaborative projects from a wide variety of companies. Recruitment activities have been unable to match the demand, and much of the effort during the year by the limited number of staff has been dedicated to defining and organizing the new projects. The standards activity

with International Standards Organization/ International Electrotechnical Commission (ISO/IEC) Joint Technical Committee 1 (JTC-1) Technical Study Group 1 (TSG-1) with respect to portability and internationalization is now complete. Technical preparatory work — detailed problem definition and selection of appropriate tools and techniques — for two large collaborative projects, one with Mitel and the other with IBM, has been completed.

Systems Integration Laboratory

Industrial and Manufacturing Systems

The Systems Integration program emphasizes the software aspects of work planning, scheduling, and process planning/ modeling as well as standards for manufacturing systems and systems used in the resource sector. One vehicle for industrial collaboration in these areas is the consortium, SIMCON. IIT has made significant progress on two consortium-defined projects. For the enterprise modeling project, all the modeling tools have been coded in an object-oriented language and the basic model is running. As part of the collaboration with PAPRICAN on systems integration technology for the pulp and paper industry, a pulp bleaching expert system was demonstrated. The ESIS project coordinated by Dalhousie University is continuing, albeit somewhat delayed by poor economic performance in the resource sector.

EMI/EMC

Culminating a successful 5-year collaboration with DND, the 10-m simulator at Defence Research Establishment Ottawa has been completed and is being commissioned. Patent protection for a pulse simulator, presently under test at the DND Quality Engineering Test Establishment, is being sought. A 200-ps generator and a facility to measure 4-ps electrostatic discharges were built. NRC is believed to be the only laboratory in the world which is presently capable of making credible measurements of such pulses, and industrial interest in both the technology and the facilities is growing.

A pulp bleaching plant that could use a diagnostic expert system.

Systems Laboratory

The program focuses on applying software technology to decision support systems for planning, scheduling, monitoring, and control of industrial operations. This program was hard hit during 1991–92 by the downturn in the British Columbia resource economy and continued uncertainty as to its future. Nevertheless, it has continued to receive recognition for its work in systems integration and symbiotic systems technology. Three staff members, J. Farlette, D. Kotak, and M. Scriabin, were awarded first prize in the Competition on the Practice of Operational Research sponsored by the Canadian Operational Research Society. The subject of their paper, AIRSYM, the airside capacity planner, has been specified by Transport Canada as one of the software systems to be used in an upcoming study of Halifax Airport, and a Canadian company is being partially funded by IRAP to commercialize the software package. As the result of efforts to

The Institute uses the level of participation by external clients as a measure of the success of its research program.

diversify the Laboratory's activities across Canada, an agreement has been reached whereby IIT, as a subcontractor to SNC Inc., will contribute its systems integration technology to the Quebec-based, 5-year, $30M PROGERT consortium for application in forest data management.

4.3 Partnerships and Services

The Institute has set this corporate priority as its highest priority, and is investing a major effort in extending and formalizing working relationships with research partners from industry, government, and universities. In less than two years, it has established itself as the Engineering Sector leader in terms of core leverage.

The Institute uses the level of participation by external clients as a measure of the success of its research program. The preferred mechanism has been research consortia or similar groupings that maximize the leverage of the Institute's resources. SIMCON has been formally incorporated as a consortium and IIT has begun work on consortium-defined projects. Two other groupings, one in optical computing, OPCOM, and the other in engine health monitoring, EHM, have attained firm commitments from the industrial members and are well advanced in both organization and in arranging financial support. Another, in the application of knowledge-based systems technology for advanced supervisory process control, is in the preliminary stages of organization.

Following the advice of its Advisory Board, IIT will attempt in future to join existing consortia, thus avoiding much of the administrative overhead associated with forming such groupings. For example, IIT's mobile robot project has recently been formally accepted as part of the PRECARN Autonomous Robot for a Known environment (ARK) project. The Systems Integration Laboratory's work in systems integration technology will be used by the PROGERT consortium, in which IIT is participating as a subcontractor to SNC. These group

Computer zoo.

More than 50% of IIT's research staff work with external clients.

initiatives are complemented by research collaboration with individual companies.

More than 50% of IIT's research staff work with external clients. In 1991–92 the Institute effort of approximately 37 py on collaborative projects was more than matched by an effort of 48 py by IIT collaborators. In total, IIT partners contributed well over $5M in cash and in kind to research projects undertaken in collaboration with the Institute. For a variety of reasons direct revenue actually decreased in the past year. However, revenue-in-kind as represented by staff members of client organizations working as guest workers at IIT remained strong, near the limit that IIT can accommodate. This year 42 guest workers contributed more than 20 py to joint projects. Examples of these collaborations follow.

New in 1991–1992

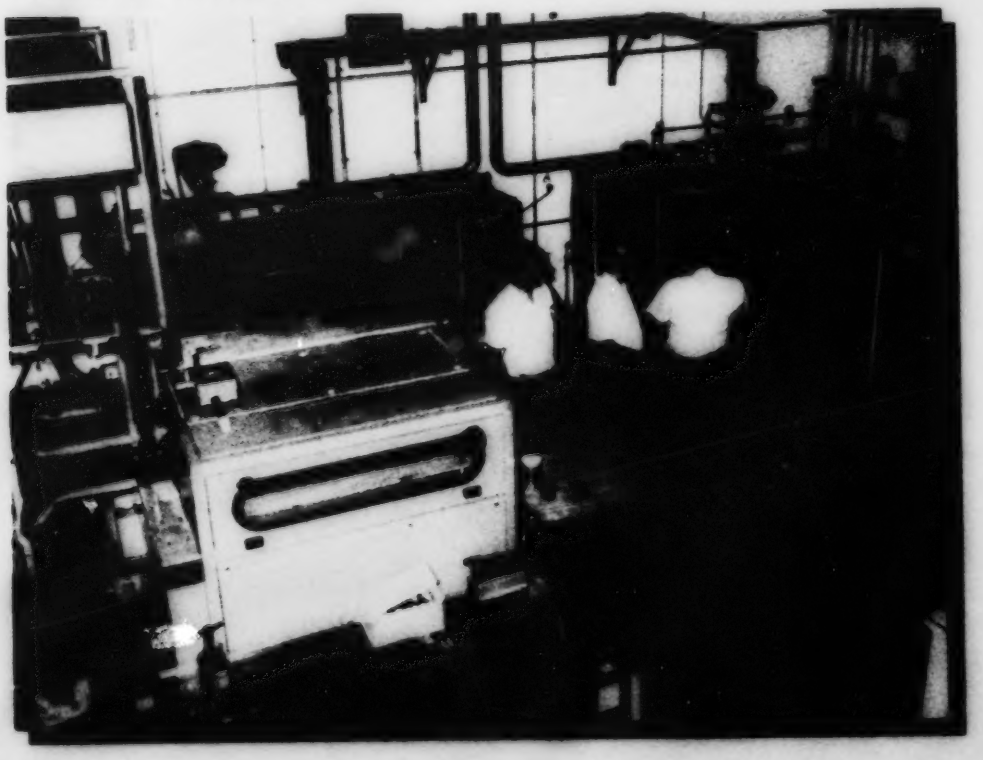
- "Systems Integration and Decision Support Systems in Forestry Management"

as subcontractor to SNC Inc. as part of the PROGERT Consortium (5 years)

- "Design Recovery" with IBM Center for Advanced Studies (2 years)
- "Formal Design Specification" with AGT Ltd., DATAP Systems, and the University of Calgary (5 years)

Continuing

- "Holographic Optical Elements for Clock Distribution" in collaboration with Digital Equipment of Canada Limited and Carleton University (2 years)
- In cooperation with the STEAR program of the Canadian Space Agency, agreements in "Autonomous Robotics" with Thomson-CSF Systems of Canada and International Submarine Engineering Ltd. (3 years)
- "Machine Learning Techniques for Process Optimization" with General Electric



The electrochemical milling operation at the GE Plant, Bromont, Quebec.

Aircraft Engines Canada, Bromont, Quebec (9 months)

- "Evaluation of the Y-Frame Scanner" with Spar Aerospace Limited (15 months)
- "Electromagnetic Protection" with the Defence Research Establishment Ottawa, Department of National Defence (5 years)
- "Database Design Advisor Project" with CSA Recherche Ltée, Laval University, and University of Leeds (3 years)
- "Airside Capacity Planning" with Transport Canada (1 year)

Through the auspices of the Telecommunications Research Institute of Ontario (TRIO), an Ontario Center of Excellence which IIT joined as an associate member in August 1990, IIT has undertaken the following projects:

- "Rare-earth-doped Glass Optical Amplifiers" with the University of Ottawa, Carleton University, and Bell-Northern Research (2 years)
- "Application of Photonics" with the University of Ottawa (3 years)
- "Optical Processing" with the University of Ottawa (4 years)

Infrastructure Support

In addition to their contributions to scientific literature and professional and standards organizations, Institute staff continue to support scientific exchange and technology transfer. Examples include

- Continuing sponsorship of a series of technical lectures, the IIT Colloquia, on a variety of topics related to Institute program areas. In 1991–92, there were 18 lectures, featuring speakers from outside the NRC.

Ultrashort pulsewidth (0.15 ps) titanium-sapphire laser developed at NRC. This technology will be used in the next generation all-optical interconnection between computers.

- Organization of a seminar, entitled "Optically Enhanced Computing," held at the National Research Council in Ottawa on October 25, 1991. Speakers were from the international photonics community. The seminar attracted about 80 participants, mainly from eastern Canada. Feedback has been extremely positive.

Several IIT staff members act as members of Editorial Boards of international journals. Examples include

- Chrostowski, J. *Microwave and Optical Technology Letters*, John Wiley & Sons, Inc.; *Optics Communications*, Elsevier Science Publishers
- Domey, J. *Industrial Metrology*, Elsevier Science Publishers
- Famili, A. *Journal of Production, Planning and Control*, Taylor and Francis; *The International Journal of Advanced Manufacturing Technology*, Springer International
- Forester, G.V. *Ultrasound in Medicine and Biology*, Pergamon Press
- Gentleman, W.M. *The Computer Journal*, The British Computer Society; *Concurrency Practice and Experience*, John Wiley & Sons
- Rioux, M. *Optics and Lasers in Engineering*, Elsevier Applied Science

IIT represented Canada at the inaugural meeting of the Japanese Real World Computing (RWC) program.

4.4 International Activities

Japan's growing presence on the world scene in advanced technologies has encouraged IIT to dedicate special effort to strengthening and expanding its ties with Japanese organizations. IIT (and previously DEE) has had ongoing technical and personnel exchanges with the Electrotechnical Laboratory (ETL) in Tsukuba, Japan, for 10 years. During the past year, Pierre Boulanger (5 months), Guy Godin (1 month), and Jacques Domey (3 weeks) visited the Machine Understanding Division at ETL to collaborate in research in 3-D vision. While in Japan the researchers also visited many Japanese companies.

Dr. Vince Thomson and Dr. Jacek Chrostowski visited ETL at the time of its 100th anniversary celebration. Dr. Nobuyuki Otsu, Director, Machine Understanding Division (1 week), Mr. K. Masuda of the Image Understanding Section of the Machine Understanding Division (1 week), and Dr. S. Ishihara of the Optical Information Section of the Optoelectronics Division (2 months) visited IIT in the past year.

Dr. Vince Thomson is participating in the feasibility study of the Intelligent Manufacturing Systems (IMS) program. This 2-year study will define a 10-year $100M/a international research program in advanced manufacturing. SIMCON research projects are being proposed for inclusion in IMS.

IIT represented Canada at the inaugural meeting of the Japanese Real World Computing (RWC) program. Dr. Jacek Chrostowski is organizing a joint Canadian-Japanese proposal to perform research in advanced multimedia applications. This project would give Canadian industry access to advanced devices from Japanese industrial laboratories.

Researchers from the Systems Integration Laboratory are participating in International Standards Organization Technical Committee 184 (Industrial Automation and Communications). Institute activity is centered on manufacturing information models, manufacturing application programming language environments, and STEP, a manufacturing information (product) exchange protocol. Dr. Udo Graefe is convenor of the working group on Manufacturing Application Programming Language Environments. As well, as part of ISO/IEC JTC-1 (Information Technology), Dr. Morven Gentleman, Head of the Software Engineering Laboratory, participated in a 50-expert 12-nation study, which resulted in the report "Standards Necessary to Define Interfaces for Application Portability." Nestor Burtnyk, Autonomous Systems Laboratory, is the Canadian representative to the Joint Coordinating Forum on International Cooperation in Advanced Robotics.

The Institute has been very active outside Canada in the area of photonics research. Collaboration has been aimed at complementing Canadian expertise in gaining access to technologies not available in Canada. Collaborations include: AT&T Bell Laboratories (active optical fibers for amplifiers and lasers), University of Duisburg, Germany (erbium-doped organic waveguides), ETL (optical implementation of neural networks), and the University of Tokyo (a guest worker, Dr. Tsutomu Shimura spent 6 months at IIT, working in the area of photorefractive materials for optical storage and processing).

Dr. Satish Kashyap, of the Systems Engineering Laboratory, continued his participation in the NATO Research Study Group on Tactical Implications of High-Power Microwaves. Dr. Andrew Podgorski continued his collaboration in lightning research with Atmospheric Research Systems Inc., Florida. He also began work in the multinational research program, Rocket Triggered Lightning Project, organized by the Atmospheric Sciences Laboratory of NASA, Kennedy Space Centre, Florida.

Mr. Michael Larkin of the Aeronautical Research Laboratory, Melbourne, Australia, visited IIT for 3 months, to work with the diagnostic systems group, through agreement with The Technical Cooperation Program (military — Canada, United States, United Kingdom, Australia). He shared his expertise by developing a base consistency checker for JETA. The Knowledge Systems Laboratory is also continuing its collaboration with the University of Leeds, United Kingdom, on the Intelligent Advisor Project.

5. Management and Administration

Our strength lies in the expertise of our people.

5.1 Industrial Liaison Office

The Institute is committed to assisting Canadian industry through collaborative R&D projects and technology transfer. In order to facilitate and support the interactions between Institute laboratories and their industrial clients and partners, IIT maintains an Industrial Liaison Office (ILO) with a staff of four. Within its overall role of business development, the ILO's main functions are to promote awareness of Institute capabilities, to help identify industry requirements and opportunities, and to negotiate agreements and working relationships with industry and other organizations. For the most part, these working relationships are in the form of cost-shared collaborative projects.

During 1991–92, considerable effort has been devoted to consortium formation and support. An alliance of companies was established that brings together an engine manufacturer and four companies that provide related support services to work jointly with IIT on knowledge-based diagnostic systems for engine health monitoring. OPCOM (Optical Processing and Computing Consortium of Canada) is being formed to team companies from across Canada with IIT, other government laboratories, and universities to cooperate on the development of optical processing systems for functions such as realtime pattern recognition. An arrangement has been negotiated with the Quebec-based PROGERT consortium in which IIT will work with the member companies in a 5-year R&D program in forestry data management and integration. Support has been provided to SIMCON (Software for Integrated Manufacturing Consortium) in helping to launch the research program and in assisting to recruit additional members.

An ILO priority during the past year has been to build up IIT's industrial client base through activities such as arranging senior-level meetings to explore potential strategic arrangements. Some of those meetings have led to negotiations on specific projects that are expected to begin in the new year. Another activity aimed at new business development has been the preparation of marketing plans for selected project areas. The plans for robotics and knowledge-based process control are now being implemented. Government departments are also IIT's clients and in 1991–92 an arrangement was formalized with the Department of National Defence in which IIT is using its knowledge of multiprocessor realtime systems to provide technical advice in a large development/procurement contract. Similarly, IIT has been providing technical assistance to the Canadian Space Agency STEAR program and has also signed a collaboration agreement with Thomson-CSF Systems of Canada that is related to the company's contract with STEAR in the area of robotics. A notable licence agreement put into place during the reporting period transferred IIT's video-rate 3-D camera technology to Hymarc Ltd. for commercialization in applications such as high-speed industrial inspection.

IIT has no major facilities to attract industry. Our strength lies in the expertise of our people. An effective way for industry to access this expertise is through participation in joint R&D projects in a collaborative, cost-shared mode. Within NRC, a measure of success in the goal of stimulating industrial R&D is referred to as "core leverage" — the level of resources (research effort, cash, equipment) that companies contribute directly to these joint projects. In 1991–92, IIT's core leverage figure was over $5 million — the highest level among NRC's five engineering institutes.

5.2 Administration

The goal of the Administration Section is to provide essential services which support the research activities of the Institute in an efficient and timely manner. The Section has 16 staff members and provides services in the areas of Human Resources, Finance, Editorial, Building Coordination, Materiel Management, and Security.

IIT is recruiting excellent new employees by building on the reputation of its existing staff ...

Since the creation of the Institute, the Section has become extremely flexible to address the ever-changing reporting and accountability requirements with a decreasing level of human resources. A new administrative structure has been put in place, with a computerized support system. This system now provides support directly to each Laboratory in the areas of materiel management, finance, and general administrative tasks.

Attracting high-calibre candidates to work at NRC continues to be a major challenge. The competition for both new and experienced staff in the field of Information Technology is fierce. However, IIT is recruiting excellent new employees by building on the reputation of its existing staff, offering a stimulating environment with the opportunity for involvement with world class research, and continuously emphasizing the value we place on our human resources.

5.3 Training and Development

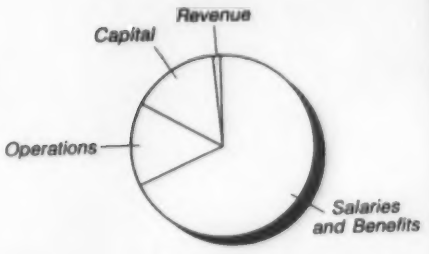
The Institute is becoming increasingly forward-looking and proactive in the area of training and development. In 1991–92, two IIT staff members were given educational leave and two others received substantial support for job-related courses. Significant time has also been invested by Institute staff in attending courses, seminars, etc. To help impart the latest techniques and technologies to outside groups, IIT works closely with visiting research scientists and guest workers from industry, other government departments, and universities. The Institute is an active participant in the Women in Science and Engineering (WISE) program, with three WISE students. As well, 24 Summer and Co-op students have been part of the Institute in the past year. Serious consideration to succession planning has also begun, to ensure continuity in achieving IIT goals.

6. Resource Profile

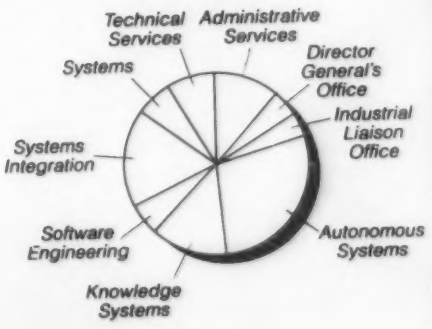
6.1 Financial Resources

Distribution of resources

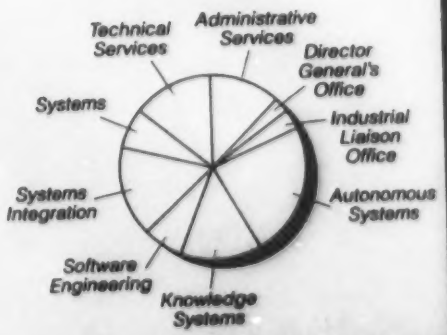
Financial resources by category
Total $11M



Financial resources
Total $11M



Human resources
114 py



Annual expenditures and revenue

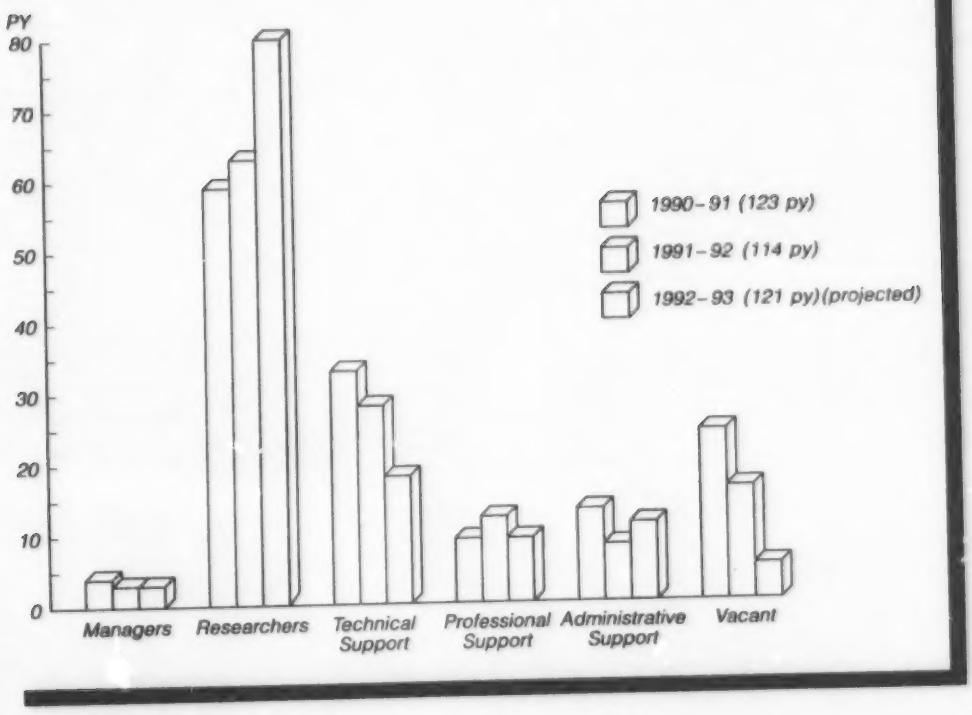
(Thousands of dollars)	1991–92	1990–91
Expenditures		
Wages & Employee Benefits	7 656	9 841
Other Operating	1 652	1 948
Capital	1 744	2 002
Total Expenditures	**11 052**	**13 791**
Revenue	**148**	**567**

Additional financial information

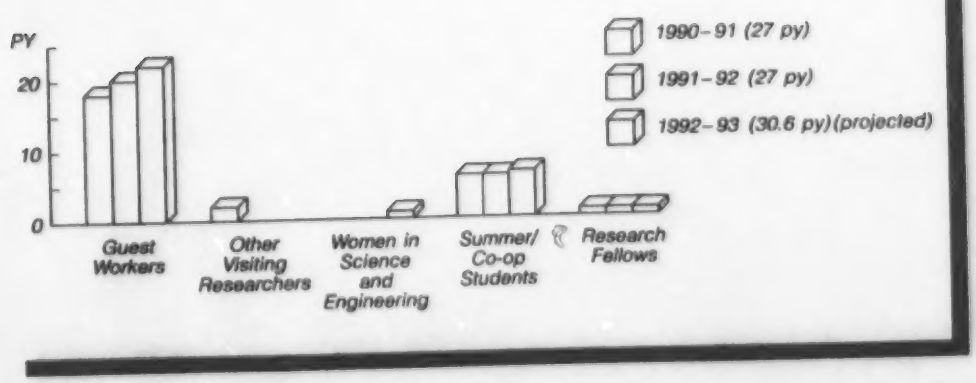
(Thousands of dollars)	1991–92
Applicable Corporate Overhead	2 638
Buildings (Historical Cost)	2 994
Equipment (Historical Cost)	18 880

6.2 Human Resources

NRC continuing and non-continuing staff



Non-NRC staff



7. Advisory Board

The Advisory Board was formed in 1990 to help NRC assist industry across Canada to achieve excellence in the systems- and software-related areas of Information Technology by ensuring that the programs of the Institute are focused and industry-oriented, and that transfer of technology is recognized as the Institute's primary measure of success.

Specifically, the Advisory Board is tasked

- to assist the management of the Institute to develop strategic and business plans and ensure, through timely review, that they are implemented
- to promote and support interactions between the Institute and external partners
- to advise Council and the NRC Executive on the management and overall priorities of the Institute

The Board met twice during the past year. Two important observations, which impact significantly on allocation of Institute resources, are noted below.

- The Board emphasized that IIT's limited resources should be concentrated towards making a technical impact. While endorsing IIT's priority of collaborative arrangements for involving industry in its research programs, the Board suggested that IIT try to join existing industrial research consortia rather than sustain the heavy administrative overhead in organizing consortia or similar groupings.
- The importance of maintaining a strong effort in generic projects was stressed. Generic or technology-based projects are defined by the strategic goals of the Institute and are the basis for the next generation of client-driven projects. It was suggested that it would be appropriate to apply approximately one third of the Institute effort to generic projects.

Members of the IIT Advisory Board are

George C. Smyth (Chairman)
President, Bell-Northern Research
Ottawa, Ontario

D.H. O'Hara (Secretary)
Institute for Information Technology
National Research Council

Dr. M.P. Bachynski
President, MPB Technologies Inc.
Dorval, Quebec

Dr. R.W. Breithaupt
Interim President, Communications Research Centre
Department of Communications

Dr. R. De Mori
Vice-President R&D, Centre de recherche informatique de Montréal
Montreal, Quebec

Dr. J. Ghent-Mallett
Director General, Information Technologies Industry Branch
Industry, Science and Technology Canada

Bruce G. Hartwick
Vice-President, Science and Technology
B.C. Telephone
Burnaby, British Columbia

Dr. Frank L. Lederman
Vice President and Director of Research
Noranda Technology Centre
Pointe Claire, Quebec

S.A. Mayman (*Ex officio* member)
Director General, Institute for Information Technology
National Research Council

J.J. Nassr
President, ICAM Technologies Corporation
Pointe Claire, Quebec

J. Ploeg (*Ex officio* member)
Vice-President Engineering
National Research Council

Dr. J.S. Riordan
Vice-President, Finance and Administration
Carleton University
Ottawa, Ontario

R. Zambonini
Senior Vice-President R&D
Cognos Inc.
Ottawa, Ontario

Annex I. Research Activities

The Institute collaborates with industry and Canadian universities to exploit these new opportunities ...

Autonomous Systems Laboratory

The objective of the Laboratory is to develop, demonstrate, and apply sensor-based automation technologies to industrial automation and to the development of advanced products. Activities are undertaken in three areas: photonic systems, sensor systems, and sensor-based robotics.

Photonic Systems

Photonics is expected to become the major information technology of the 21st century, complementing the spectacular achievements of electronics in the latter part of the 20th century. Use of photons in addition to electrons makes available a fully parallel processing capability, extra large bandwidth, and global interconnectivity. Photonic systems are already competing in applications which traditionally have been the preserve of electronic computing technology. Optical data storage is an example of their success in the market place. Photonics and electronics are often combined to develop new processing systems for applications in, for example, robot vision and high-level pattern recognition. Optical interconnection of electronic processors at the board-to-board and module-to-module level brings many new capabilities and much improved functionality. The Institute collaborates with industry and Canadian universities to exploit these new opportunities and take advantage of their far reaching potential.

A highlight of the year has been the development of a compact Q-switched erbium doped fiber laser. Since the human eye is opaque at its emission wavelength of 1.5 µm, this laser is "eye-safe" for applications in laser radar. A number of companies are actively soliciting IIT's expertise in this technology. Furthermore, the fiber laser holds great promise in all-optical communication networks. An industrial agreement to develop this area has been established with MPB Technologies of Montreal, Bell-Northern Research, and the Telecommunications Research Institute of Ontario (TRIO).

Collaboration with Digital Equipment of Canada and TRIO in computer-generated holographic and guided wave devices for interconnects has continued. New approaches based on simulated annealing and genetic algorithms have been demonstrated for highly complex interconnect schemes.

The Institute for Information Technology is leading a new national initiative in optically enhanced computing technology. A consortium (OPCOM) of 5 Canadian companies, several research institutes, other government departments, and 13 universities is finalizing the definition of a technical program to build an up-to-teraflop (10^{12} operations per second) specialized processing system with low power consumption and small volume, suitable for mobile use. Applications for this capability include realtime pattern recognition (radar, sonar, DNA sequencing), synthesis of multi-sensor data (remote sensing, avionics), and low-power intelligent autonomous systems (space, robotics).

Sensor Systems

The objective of this subprogram is to provide innovations in the field of optical sensing technology to Canadian industry. The activities of the group cover two complementary areas: digital 3-D imaging and software tools for machine vision. Since 1982 the group has built, demonstrated, and patented several sensors for three-dimensional measurements. Two licensees currently exploit the technology in the fields of robot vision and dimensional inspection.

During the past year, the high-resolution random access laser scanner was used to capture the shape and the monochromatic reflectance of a scale model (1/4) of the space shuttle cargo bay (about 5 m in length). A single panoramic view covering about 150° has been used to digitize the entire cargo bay interior surface. The dimensional noise is on the order of a few millimetres, and a 1000 by 2000 pixel image has been recorded. The 3-D file is used as a model in a computer simulation

of Canadian astronaut Steve MacLean's flight, scheduled for October 1992. The laser scanner prototype is still under development. We have purchased the components for its operation at 1.5 µm (eye-safe) and will integrate them next year. We have also initiated the development of strategies for realtime tracking of geometrical features in order to eliminate the need for the special purpose targets required by present-day tracking systems.

... satellite transmission of color 3-D images was demonstrated in collaboration with Telesat Canada.

During the Engineering Institutes' Open House in October 1991 (part of NRC's 75th anniversary celebration) satellite transmission of color 3-D images was demonstrated in collaboration with Telesat Canada. Data files were stored at Telesat's Montreal Teleport earth station and called up by telephone computer link from Ottawa. Image data files of approximately 1 Mbyte were then transmitted to Telesat Anik's C1 satellite at a transmission rate of 56 kbit/s and instantaneously relayed to a 2.4-m earth station at NRC in Ottawa. Once received, the image was stored in a Silicon Graphics workstation and presented in 3-D (viewed using special glasses) on a high-resolution monitor.

Universities and industry have shown increasing interest in the BIRIS prototype during the past year. Within the Laboratory it has been integrated with the mobile robot, providing panoramic 3-D sensing. A project to demonstrate this 3-D vision technology for the forest industry was initiated in collaboration with the Forest Engineering Research Institute of Canada (FERIC) and applications in the mining industry are currently being evaluated.

Collaboration is continuing with the Electrotechnical Laboratory (ETL) of Japan (an exchange of researchers), the Canadian Space Agency, the Canadian Conservation Institute of the Department of Communications, several universities (Laval, Concordia, Waterloo), and the NRC Institute for Mechanical Engineering (IME). With IME stereolithography has been used to directly copy objects. Contracts are ongoing with Hymarc Ltd., Les Consultants Genicom Inc., l'École Polytechnique, and Spar Aerospace Limited. One of the contracts involves transfer of the video-rate laser scanner technology to Hymarc under a Phase II STEAR project (CSA).

The program to develop software tools for machine vision is beginning to gain momentum. Automated segmentation using hierarchical grouping based on optimal region growing and geometrical generalization has been achieved. Pose determination and refinement using random sampling and robust fitting has also been demonstrated. These software tools are used with 3-D data files. Laser scanned data for planar and second-order surfaces have been geometrically described. Users have been identified (in the fields of communication and sports equipment) and two software companies are presently evaluating this approach with the intention of commercializing the technology.

Sensor-Based Robotics

The sensor-based robotics subprogram involves development of advanced algorithms for interpretation of sensory data and control of robot manipulators and mobile vehicles in unstructured environments. The group's mandate is to work with Canadian industry to enhance its competitive position.

The Institute has demonstrated an experimental telerobotic system that bridges the gap between pure teleoperation and full autonomy. Earlier work provided a man–machine interface for acquiring a model of the environment and supervising the robot manipulator activity. This past year, the man–machine interaction was extended to include collision-free path planning and increased environment modeling flexibility.

Other robotics activities in progress include investigation of fault detection during robot manipulation, using statistical models and pattern recognition, and development of "skills-oriented robot programming," based on graphical interaction between the operator and a programming workstation. Maestro, an object-based architecture for realtime multi-robot control, is presently in the debugging phase. It

Supervised Autonomy: Man–Machine Cooperation in Telerobotics

"Supervised autonomy" is IIT's approach to man–machine methods for robotics applications requiring a significant degree of human control, allowing the system to perform work in hazardous environments such as space, nuclear power plants, underwater, mining, and utility maintenance. The concept is equally applicable to robot manipulators and mobile vehicles in unstructured environments. This technology is currently under evaluation by a number of Canadian companies.

Supervised autonomy optimizes the usefulness and productivity of a robotic system by division of operator and computer control based on their relative capabilities. Humans are superior at high-level perception and reasoning, whereas a computer is better at low-level sensing and control. Therefore the operator is responsible for understanding the robot's environment and planning the robot's tasks, and the computer controls precise positioning and manipulation.

At IIT we have demonstrated a prototype system based on this principle. The operator identifies objects in the environment and their approximate locations; the robot then operates under computer control to determine the precise locations of the objects using a wrist-mounted laser scanner, and carries out sequences of movements and manipulations as commanded by the operator.

Application of this technology is being carried out in collaboration with Thomson-CSF Systems of Canada and International Submarine Engineering Ltd., two contractors currently developing advanced robotics systems for ground-based support of space robots, particularly the Special Purpose Dextrous Manipulator, under the STEAR program of the Canadian Space Agency. Opportunities for exploitation are also being pursued with companies in the space, energy, and mining sectors.

directly accommodates the integration of sensory functions and will be used as a basis for ongoing robotics activities.

Some of this work is carried out in collaboration with Thomson-CSF Systems of Canada and International Submarine Engineering Ltd., two contractors who are developing advanced robotics technology for ground-based support of space robots, particularly the SPDM, under the STEAR program of the Canadian Space Agency. Opportunities for exploitation of this technology are being pursued with companies in the mining, space, underwater, and energy sectors.

In autonomous navigation, we have used ultrasonic sensors on board the IIT mobile vehicle to demonstrate and compare three realtime reactive collision avoidance algorithms: the potential field method, the generalized potential field method, and the sector elimination method. The algorithms augment human operator control with automatic collision avoidance and with them we demonstrated collision-free autonomous operation of the vehicle. A new processing algorithm has been implemented to improve the functioning of the sonar system, providing an order-of-magnitude speedup in data acquisition and a significant improvement in signal-to-noise ratio.

The group has completed ODD, a software system for On-line (Data) Display for robot sensor data. It provides a flexible user interface to the runtime system that is important both for development and for operating purposes. It allows multiple streams of sensor data to be simultaneously presented as graphics on a color Macintosh screen. A flexible protocol, a reconfigurable server, and an object-oriented design for the display/communication program make ODD a valuable tool for both the mobile vehicle and the robot manipulators.

Low-level integration of IIT's BIRIS laser range scanner into the mobile vehicle's system architecture has been completed. We have also completed a port of Harmony release 4 for the Motorola 68040 microprocessor. In the coming year this system will be evaluated for possible use as the basis for all mobile vehicle onboard computing. Other activities in progress include development of a new blackboard-based control architecture supporting both high-level decision making and low-level realtime navigation, mobile vehicle localization through integration of local sensing with a global map, and the investigation and development of floor level sensing methods and strategies for traversal of critically sized floor obstructions.

Opportunities for exploitation of mobile platform technology are being pursued ...

Much of the mobile vehicle work is being carried out in collaboration with Ontario Hydro, Atomic Energy of Canada Ltd., York University, and the University of Toronto through a PRECARN project. Opportunities for exploitation of mobile platform technology are being pursued with mining and service companies and for space, defence, and security applications.

Knowledge Systems Laboratory

The Laboratory performs research and development in the area of applied artificial intelligence with a focus on knowledge-based systems. Activities are undertaken in three areas: intelligent advisor systems, diagnostic systems, and machine learning.

Intelligent Advisor Project

This project is aimed at the development of basic software technology that supports the creation and implementation of advisor systems. Applications have been identified in collaboration with industry and other government departments and have been selected to drive the development and to demonstrate the feasibility of the intelligent advisor concept. The generic technologies investigated within the scope of the project include knowledge representation, reasoning techniques, user models, tutorial strategies, response generation, and user interface design.

The basic framework for the Intelligent Advisor continues to be developed within the application domain of database conceptual modeling. A general Design Application Model has been integrated into the prototype to support the composition of questions. Currently, four of the identified question types have been implemented. The remaining eight types build on these basic types. The design of the tutorial module has been revised to correct timing problems encountered in the initial implementation. Work has been initiated on the case generation facility that will allow the expert to generate training cases directly. During the next year, the prototype will be sufficiently complete to allow initial user tests. We will emphasize increased industrial participation in this aspect of the project.

We continue to collaborate with the Systems Integration Laboratory in the development of software design aids to assist engineers in creating systems hardened against electromagnetic interference. That collaboration has been enlarged to include a program of research in Electromagnetic Interactions at The University of Western Ontario. During the current fiscal year, enhanced electromagnetic interaction modeling software based upon ideas taken from the theory of fuzzy logic was completed. Plans for fiscal year 1992–93 include development of a user interface based upon HyperNeWS1.5 for the new version of the modeling software and a conversion of the software from Prolog, in which the present system is written, to the language C++.

At the request of the Department of National Defence (DND), the group prepared a proposal for the development of an advisor application in the domain of navigational aids. DND requires an advisor system to assist its personnel in the selection of suitable Tactical Air Navigation System (TACAN) sites. The IIT proposal suggested a two-phase 3-year project. The first phase will involve design, specification, and prototype implementation of a TACAN design tool. This proposal was approved in late October. Plans for fiscal year 1992–93 include completing the three tasks in Phase One: knowledge acquisition, specification, and prototype implementation.

Diagnostic Systems

The objective is to develop supporting tools and methodologies for the design of diagnostic, planning, and control systems. Currently there are two projects within the subprogram: engine health monitoring and realtime expert systems.

The engine health monitoring project, undertaken in collaboration with the Institute for Mechanical Engineering's Engine Laboratory, is part of a larger study of engine condition monitoring. To date the

Laboratory has developed the following prototype software:

- the Jet Engine Troubleshooting Assistant (JETA), a comprehensive knowledge-based system designed to aid technicians in the diagnosis of jet engine faults. This system combines the troubleshooting network derived from maintenance manuals with the heuristics of experienced technicians. JETA has been developed as a set of software modules which can be applied to more than a single engine type. It incorporates an advanced user interface which displays pertinent graphics and hypertext advice to the user during a troubleshooting session.

- a knowledge-base management tool kit which allows complex knowledge to be viewed and edited graphically. The user can define his own frame-based knowledge representation, display various relationships and control logic within the network, and edit the contents of a particular frame.

- application of machine learning and statistics to sensor data pattern analysis.

The formation of an industrial alliance to provide an integrated diagnostic system to flight line technicians for commercial aircraft engines has been negotiated. A feasibility study for this project, partially funded by Industry, Science and Technology Canada, has begun.

The expert system component of IMAFO will be used by GE staff for problem solving and process set-up.

The realtime expert systems project investigates applications of AI techniques, including rule-based and model-based reasoning, to industrial process control. During the next year, industries will be invited to subscribe to a program that will provide them with access to knowledge-based process control technology and the opportunity to participate in applications of the technology currently under development in the laboratory.

We continue to work on two previously developed AI tools, Fuzzy_CLIPS, a fuzzy inference engine, and BB_CLIPS, a control blackboard architecture. Fuzzy_CLIPS was extended to make fuzzy-set specification more flexible and to support "de-fuzzification" of fuzzy sets. It has also been demonstrated on a test problem (fuzzy logic control of a shower). Next year the system will be tuned to improve performance. BB_CLIPS is being tested by the Systems Integration Laboratory (scheduling) and by the Autonomous Systems Laboratory (robot control).

Past investigation of qualitative reasoning has allowed us to use qualitative reasoning to perform on-line diagnosis of processes. Next year we will build a prototype to demonstrate this technique.

A domain independent language for representing and transforming models of dynamic systems was developed, a prototype built, and the method evaluated on tasks like sensor data analysis, diagnosis, and planning. In the coming year, other operators will be developed, the prototype extended, and other applications studied.

Machine Learning

The objective of this activity is to apply machine learning techniques to the development of knowledge acquisition tools that have broad applicability. Work is currently underway in three application domains.

The Intelligent MAnufacturing FOreman (IMAFO) is being developed as a general tool that can be used to analyze information from a discrete manufacturing process in order to improve that process. General Electric formally began a joint project with NRC in January 1991. Phase 1 of this project applies IMAFO to process optimization of the Electrochemical Milling operation at GE's plant in Bromont, Quebec. Future phases will involve the development of the expert system component of an intelligent supervisory system. Phase 1 of the GE–NRC project is nearing completion. The results of the analysis made by the learning component of IMAFO will be used to build the knowledge base of the expert system component. The expert system component will be used by GE staff for problem solving and process set-up. Evaluation of IMAFO with simulated and real applications has

IMAFO

The goal of this project is to design and implement an intelligent supervisory system to monitor and analyze plans and operations in an industrial environment, explain why certain plans fail, and suggest appropriate actions. Areas where this system can help planners, engineers, and operators include process control, process optimization, planning, and cost and quality control.

The system will have two parts: a learning component and an expert system component. A prototype of the learning component, called IMAFO (Intelligent MAnufacturing FOreman) was built and is currently being used for a complex industrial process. The expert system component is being designed.

IMAFO uses machine learning techniques to analyze data from an industrial process. It looks for patterns in the success and failure of plans and operations and generates rules for predicting when a plan or operation will succeed or fail. IMAFO can discover new knowledge and fill gaps in the domain knowledge of experts.

The role of the expert system component will be to provide advice to operators and engineers on what should be done to improve the performance of an industrial operation. The expert system component will encode and store the domain knowledge of experts and the knowledge generated by IMAFO.

General Electric Canada in Bromont, Quebec, is involved in the testing of IMAFO. IMAFO is used in that plant for process optimization of the Electrochemical Milling operation. GE-Bromont will also be involved in the development of the expert system component. We are currently looking for software companies to participate in the development of the remaining components of the intelligent supervisory system and commercialization of the technology.

revealed limitations to the interface of the current version (Version 0.5). Work on a new version (Version 1.0) is nearing completion. In Version 1.0, the interface and the initialization mechanism have been restructured and a more advanced user interface development environment (GUIDE and LISPview) has been used.

The group is collaborating with the Ottawa Police to develop an expert system to aid the investigation of residential break-and-enter incidents. Break-and-enter investigators have identified parameters which they consider important to the investigation of a case. The same investigators are now identifying why this information is important, i.e., what it might tell them about the offender. This process will lead to the generation of a knowledge base that will then be used to generate a profile of the offender. This profile can be matched against profiles of known offenders to produce a list of possible suspects. Once the significance of each of the parameters has been determined, a data gathering form will be designed and put into use. Consideration is being given to use of a machine readable form to ease the data entry burden.

Diagnosing faults in gas turbine engines is a complex problem. The goal of the Data Interpretation Tool For Engine Diagnosis (DITFED) project is to develop improved methods for the diagnosis of gas turbine engines, by applying machine learning technology to the analysis of sensor data. A new learning strategy for analysis of the sensor data, using linear regression and instance-based learning, has been investigated. The learning strategy was developed and tested using extensive transient data from a jet engine in the test facilities of the Institute for Mechanical Engineering. The learning algorithms provide rapid diagnosis (about 40 s) and useful accuracy (about 70%). These results suggest that the techniques can be the basis for a tool that will provide substantial support to engine repair technicians. Future work will examine the feasibility of extending our approach to a fleet of engines. We will also explore the application of neural networks to engine diagnosis.

Software Engineering Laboratory

The Laboratory performs research and development in software engineering — all the practical aspects of developing and supporting software. Specific projects are in the areas of realtime and embedded systems, commercial software products, and large-scale systems.

Realtime and Embedded Systems

Release 4.0 of Harmony took longer to complete than was anticipated at this time last year, but it has now been given to Precise Software Technologies, the licensee and distributor of Harmony. One delaying factor was that a gap was revealed in the way our configuration management methodology was applied. This gap, through inattentive management and undisciplined programmers, could lead to contamination of the code tree. A remedy was found and applied. Major changes to our main development platform also contributed to the delay. System 7, the new Macintosh operating system, and MPW 3.2, the new programming environment, improved facilities but necessitated redevelopment of some of the supporting tools.

Close coupling of Harmony with a foreign operating system is required both during development, when programmers cross-develop using a different system from the target where the realtime application will run, and during production, where the operator interface is often implemented on a mass market graphics computer rather than on the realtime system itself. As part of the evolution of Harmony, research in the last year has focused on how best to do such close coupling when Harmony and the foreign operating system are implemented on different cards on a common backplane.

... most-advanced project is a collaboration with IBM and others on design recovery.

Understanding the ramifications of new processors is important for operating systems research. The caching and address translation features of the Motorola 68040 are significantly different from other processors we have used. Time was spent understanding how they should be used to port Harmony to such a machine. This understanding was also useful in helping a client company evaluate the design for a multiprocessor avionics computer they were proposing to build.

The Canadian Towed Array Sonar System (CANTASS) which DND is building includes both large multiprocessor shipboard and shore-based systems. Our involvement on this project has led us to research many topics arising from issues in the development of these production systems. A prime example is the use of optimistic concurrency control to improve the performance of a large system with many heterogeneous processors. Another is the use of data compression to improve download times by reducing the size of executable images. Still another is the study of what is available, or can be built up around independent products, as software development environments for Ada programs, especially low-cost environments. Considerations in the use of RAID (Redundant Arrays of Inexpensive Disk) storage systems was yet another interesting topic.

Work in user interfaces included research in visualization to support configuration management methodology. It also included research in how to do a better job of the symbiotic communication between a graphics computer that actually interacts with the user, and the remote computer whose processing it represents.

Commercial Software Products

This subprogram is still in early stages. The team leader has joined IIT and staffing is under way. Most of the work accomplished to date has been on the portability and internationalization project. Other projects, such as field support for products shipped in volume, are only in a definitional stage, and industrial collaborators are actively being sought.

Large-scale Systems

The principal activity in this new subprogram has been project definition. Four have been chosen.

The most-advanced project is a collaboration with IBM and others on design recovery. Design recovery is examining the existing artifacts of source code and executable images of legacy code to determine design decisions their implementors took. Such programs are often 10 or 20 years old, their designers are no longer available, and the documentation is

typically inadequate, obsolete, or nonexistent. Detailed design information is necessary to maintain or evolve the existing code, or to implement a successor while preserving continuity of business procedures. IIT's part of the project is complementary to the approach our partners are taking: we are examining executable images by pseudo execution and are examining source code by full text searching techniques. Initial efforts have been to use the Icon language to formulate and search for patterns that recognize specific design decisions. An early success came when looking at a large program that had five instances of a particular abstract data type. Abstract data type technology hides internal representation, so the implementation of all five instances could readily be changed. However, in this case instrumentation had shown that one of the instances needed a different representation

Software Portability

Portability is the property of a program that ensures that it can easily be moved to run on different computers. It is of greater importance today than ever before. For commercial software products, it increases the size of the potential market, not just because the product is available on other individual platforms, but because some customers need products that are simultaneously available on all the platforms the customer uses. For large-scale systems, it addresses the problem that critical software systems have longer lifetimes than the hardware and software platforms on which the systems run. Such systems must therefore be prepared to be moved to different platforms. Surprisingly, even embedded systems with hard realtime constraints and unusual peripherals can be made to be portable.

Standards play a part in portability, for software conforming to a standard can be run on any hardware and software platform supporting that standard. The Laboratory has been involved in standards work with TSG-1, the technical study group set up by JTC-1 of the International Standards Organization (ISO) and the International Electrotechnical Commission (IEC) to investigate what changes were needed in standards in order to improve application program portability. The final report of TSG-1 last year led to a new activity, reviewing application environment profiles, which are lists of standards pertinent to particular types of applications.

More basic than standards, however, is finding abstractions in terms of which the applications can be written, where the abstractions can be realized on any of the platforms to which the application may potentially be moved. The core of the application depends only on the abstraction, so requires no changes between platforms. Tools to assist the realization of the abstraction can also minimize the porting effort. With appropriate abstractions, the realization on different platforms can provide local look and feel, can exploit specialized hardware or other local facilities, and can accommodate for interoperability with third-party products that may differ even between instances of a single platform. Included in the abstractions investigated in the last year were graphical user interfaces for software development tools. Dependence on the availability of specific development tools is a much bigger portability problem for Ada programs, for instance, than is the instruction set of the development system or of the target on which the program will eventually run. A different level of abstraction which was investigated was how to cope with the fact that the development system and the target system might use a different byte order to represent numbers (big endian versus little endian), especially in the face of the situation that different peripheral devices used simultaneously with a given target may each also require a different byte order.

This project is concerned with a specific program of almost three million lines of code.

from the other four. By means of pattern matching we established that the uses of the data type in the source code were clearly separated into references related to the instance which needed the different representation and references related to the other instances, so the change in representation was easily made.

Another project with an industrial client is in the area of software reuse. This project is concerned with a specific program of almost three million lines of code. The client is interested in recognizing commonality throughout the code and representing it nonredundantly, both because the reduced mass of code should improve maintainability, and because those common elements probably can be carried forward to future products.

A technique proposed for improving the quality of software and for convincing third parties of that quality is the use of formal methods. These methods derive the program by a sequence of mathematical transformations applied to a mathematical statement of the program specification. As such, they can, in a specific sense, prove the program to be correct. A joint project has been established with two Alberta companies, AGT Ltd. and DATAP Systems, and the University of Calgary to gain a working familiarity with such methods by investigating their applicability to the companies' businesses.

Safety critical software is a major concern of software engineering, and several methods have been advocated to ensure its trustworthiness. Through the Institute for Risk Research at the University of Waterloo, we are in a collaboration to try to quantify the effectiveness of these methods. A specification has been produced for a generic problem, the control of a hot water boiler, and the proponents of various methods are using these methods to implement the specification. The Software Engineering Laboratory is building an exerciser to test the resulting programs for possible flaws. The results of this experience will be presented at a symposium in 1993.

Systems Integration Laboratory

The Laboratory performs research and development work in applications of information technology to the integration of systems and processes for Canadian industry and in the area of electromagnetic interference/electromagnetic compatibility. Activities fall into two project areas: industrial and manufacturing systems and electromagnetic protection.

Industrial and Manufacturing Systems

The objective of this program is to apply information technologies to the integration of systems and processes to improve the competitiveness of Canadian industry. The aim is to develop and apply computer-based tools to the planning and management of Canadian manufacturing and resource industry operations and to transfer integration software technology to industry for product creation and productivity enhancement. The emphasis is on collaboration with other groups, both within NRC and external partners. The link to industrial technology users and technology suppliers is particularly important.

In the manufacturing area, IIT is collaborating with a consortium of companies (SIMCON) to perform precompetitive research in computer-integrated manufacturing. Current SIMCON members are EDS Canada (Toronto), Interfacing Technologies Corp. (Montreal), and Phoenix Systems Synectics, 1991 (Ottawa). Additional members are being recruited. Significant progress on two SIMCON projects was made during the past year. The first, Enterprise Modeling, involves the modeling of operations and integration of the information and control flow in a manufacturing enterprise. The second project, Manufacturing Data Integration, deals with the development of a standards-based method for information sharing among various information processing modules. A number of tools have been developed for the processing of the emerging international data exchange standard PDES/STEP and its integration with database management systems. Currently the integration between

Enterprise Modeling

The Enterprise Modeling Project is one of the projects jointly carried out by the Institute and SIMCON. The objective is to provide a comprehensive set of tools for the creation of models of manufacturing systems for assisting decision making in a manufacturing environment. The scope of the modeling tool includes all aspects of the operation of a manufacturing enterprise, from business operations to shop floor production operations. The models can be used to improve the ways in which manufacturing facilities are managed and operated. Based on an ISO Reference Model, a framework for a six-level hierarchy, encompassing the enterprise, facility, department, cell, workstation, and equipment, has been defined. A series of prototypes of the Enterprise Modeling System is planned, each being a progressively more comprehensive version of a basic prototype model created by incorporating implementation of a cumulative set of model functionalities and manufacturing decision support capabilities. The prototypes will result in a general framework for the Enterprise Model, including a Generic Activity Model, which can serve as a template for modeling a range of activities within the enterprise.

Software development is based on Smalltalk-80 on DECstations. The flow of materials in a production department has been modeled at the department and cell levels. A user interface allowing entry of process plan and schedule data, view of the simulated activities, and review of model outputs, has been developed. A purchasing department will be modeled next. The applicability of those functionalities developed for the production department to the purchasing department, and the integration of the two departments, will be the major focus.

PDES/STEP and existing standards such as IGES and EDIF is being examined. A third project, Assembly Management Information System, is in the requirements definition phase. A project with the Reynolds Aluminum Co. of Canada for the integrated scheduling of one of their heat treatment and rolling facilities has just begun.

The main goal in the resource industry area has been to develop decision support systems for design, management, and supervision of industrial operations in mines and pulp and paper mills. Most will integrate software tools such as models, expert- or knowledge-based systems, algorithms, user interfaces, and database managers. In collaboration with PAPRICAN and CP Forest Products an expert system has been developed to help diagnose operating problems in bleach plants for wood pulp. Other projects dealt with the integration of model-based tools into a mill-wide quality management system. A prototype of a model-based tool for mill production management was demonstrated.

Steps were undertaken to try to form a consortium of pulp and paper companies and their suppliers for the development of mill applications of decision support systems. To this end, we co-sponsored a "Pulp and Paper Expert Systems Workshop" with the Centre de recherche informatique de Montréal. Participation is being negotiated in two large-scale projects, one in forestry data management and integration (PROGERT) and the other in surface mining, both involving integration of decision support tools.

The development of effective user interface tools and reusability of code between the many applications is of utmost importance. During the past year a major effort has been invested in the acquisition and use of object-oriented design and programming techniques.

Electromagnetic Protection

This program concentrates on electromagnetic protection research of interest to industry, the Department of National Defence (DND), and other government departments. As a part of an agreement between NRC and DND, two NRC scientists are located at the Defence Research Establishment Ottawa (DREO). Complementary facilities exist at IIT and DREO.

A number of industrial and other government department clients have been assisted over the past year to overcome electromagnetic protection problems. Measurement of electromagnetic coupling into the firing circuit of a rocket motor for Bristol Aerospace of Winnipeg is one of many examples.

At IIT, research and development has continued in the areas of expert systems, EM field simulation, and wide-band measuring systems. The NRC-developed expert system for EM hardening is being elaborated and validated in cooperation with DREO and The University of Western Ontario. The group has constructed several broadband EM field simulators and testing has been done up to 3 GHz in cooperation with the DND Quality Engineering Test Establishment (QETE). Pulse testing and testing in an anechoic chamber are planned. In the area of pulse sources, a commercial 200-kV 2-ns pulse generator was modified to achieve <200 ps rise time by using a pulse shaping switch. Advances have also been made on the pulser technology. These include the development of a sub-50-ps rise-time 200-kV pulse generator. This generator was used to measure the rise-time characteristics of the 10-m EMP Simulator at DREO.

At DREO, development of analytical and measurement capabilities continues. Construction of the 10-m simulator for system level EMP measurement is completed. A 600-kV pulse generator has been purchased and is presently being installed. Preliminary characterization of the simulator has been done using lower voltage pulse generators, some of which were developed at IIT. Minor modifications were done to the load taper to minimize the reflections. The preliminary characterization also showed that the fields outside the simulator taper off quickly and that the measurements confirm the previous calculations. In the next few months, the performance of the pulse generator will be verified and system level measurements initiated.

A 2 m × 2 m × 6 m transverse electromagnetic cell (TEM) for pulse as well as cw measurements has been constructed. A 50-kV pulse generator forms an integral part of the input transition of this TEM cell and can be easily interchanged for a cw transition.

In the area of electromagnetic interaction analysis, new software for factoring a general matrix has been developed. This software practically eliminates page swaps when moment-method-based equations that are too large to be saved in the core memory are solved. The software has been used in a number of moment-method-based codes. In addition, DIDEC.DREO, a program developed in cooperation with Concordia University, has been enhanced to include creation of wire grid, surface patch, and cell models for electromagnetic interaction analysis of a structure. Considerable effort has also been spent on the development of a time domain extrapolation technique based on the singularity expansion method (SEM). This technique allows extrapolation of a measured time domain response for one incident waveform to the response for a different incident waveform. Measurements have confirmed the predicted analytical results.

... technology that caters to the creative capability of human experts ...

Systems Laboratory (Vancouver)

Modern industries are becoming larger and more complex. The resource and transportation industries, e.g., forest management and airports, are examples of this phenomenon. Decision makers at all levels need more information to supplement their experience and expertise. Even under the best circumstances the job of the typical manager or engineer has become more demanding and onerous. Traditional information systems sometimes actually increase the complexity of the decision-making process. This happens particularly when the system requires the human to adapt to its needs, as opposed to the system catering to the human.

Research in the Systems Laboratory focuses on the development of Symbiotic Systems technology that caters to the creative capability of human experts, the use of object-oriented programming systems (OOPS) which are well suited for symbiotic solutions, and creation of Layered Architectures that maximize the use of resources invested in existing technologies, such as databases, models, and geographic information systems (GIS).

Resource and Transportation Industries Support Systems

The application focus of the Systems Laboratory is on planning, scheduling, monitoring, and control systems for the resource and transportation industries. Applications are developed in collaboration with industrial partners representing both the "users" and the "suppliers" of technology. Application projects are backed up by internal research projects aimed at extending the boundaries of the technology. During the past year the emphasis has been on commercialization of the forestry and airport technologies developed and field tested the previous year. Several projects have been completed.

Phase I of the airside capacity planning symbiotic system (AIRSYM) is now completed. AIRSYM is being used by Aviation Research Corporation (ARC) in collaboration with NRC to develop a master plan for Halifax International Airport. In addition, ARC is working with the Laboratory to develop an Apron Management and Planning Symbiotic System (AMPSYM). AMPSYM will help airport planners evaluate the effect of alternate apron and gate designs and gate allocation strategies. AIRSYM and AMPSYM are the first of a series of modules aimed at planning and design of airports.

In the area of forestry planning and management, an object-oriented system called Long Term Planning was developed in

Airport Capacity Planning Symbiotic System (AIRSYM)

Although computers can now solve large and complex problems and will continue to become more powerful, many classes of problems remain which depend on human creativity and visualization for good solutions. Designing an airport layout to optimize aircraft movements falls into this category. The symbiotic systems approach to solving this problem has demonstrated considerable promise. A symbiotic system comprises at least one human expert interacting with at least one computer in such a way that each benefits from the other. When information is presented to human experts, they do not see exactly what is there. Rather, the scenario they visualize is influenced by memories of past experiences. Symbiotic systems support and use human visualization for solving complex problems that can be represented visually. In symbiotic systems the computer uses traditional methods from areas such as operational research and artificial intelligence, but also supports those human visual and creative abilities which cannot be automated.

AIRSYM is the result of a joint Transport Canada/Transportation Development Centre/National Research Council research project. It is a symbiotic system combining expert systems, object-oriented programming, quantitative algorithms, and optimizing methods in a visual interactive simulation. It allows the user to dynamically create, position, and move runways and taxiways while the simulation is running and observe the effects on the throughput of the system. AIRSYM has been validated at Vancouver International Airport, where it was found to produced realistic results.

AIRSYM has been so successful that four spinoff research projects have been generated. Experiments continue, with sound being used as a trigger for human visualization. A non-disruptive "thinking" agent is also being designed to perform lengthy optimizations which provide prescriptive help to the planner, such as suggesting the initial location of multiple rapid exits on a runway. At appropriate times the thinking agent signals that it has advice to give.

... a forestry supervisor can prepare a 5-year plan and immediately go on to prepare a detailed harvesting schedule for its first year.

1991–92. Forest companies are required to submit official 5-year plans showing the exact sites to be logged during each year and season. Information required to prepare these plans, which usually take several professional foresters several months to prepare, comes from a variety of sources, including GIS and relational databases.The Long Term Planning system was integrated with an enhanced version of the Short Term Scheduling system (developed in 1990–91). Using the integrated system, a forestry supervisor can prepare a 5-year plan and immediately go on to prepare a detailed harvesting schedule for its first year. The system is being field tested by a British Columbia forestry firm. The Laboratory has now been invited to participate in a major Quebec-centered forest management information systems project. PROGERT is a 5-year $30 million research project spearheaded by SNC Inc. The Laboratory will be contributing its expertise in symbiotic systems, object-oriented programming, and layered architecture.

AUDITION, an object-oriented programming language, was enhanced by the Laboratory and licensed for commercialization to a Vancouver firm. Significant enhancements include the ability to build larger applications on 386/486-based computers, to add knowledge bases to objects, with each object inferring from its own knowledge base, and to send complete objects from one computer to another over a local area network. These enhancements are used by the application projects currently under way and are in the process of commercialization.

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- **Myslinski, P., Chrostowski, J., Koningstein, J.A., and Simpson, J.R.** High power Q-switched erbium doped fiber laser. *IEEE J. Quantum Electron.* 28(1): 371–377; 1992. NRC 33142.

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- **Necsulescu, D.S., Jassemi, R., Kalaycioglu, S., Jacob, D., and Elgazzar, S.** Impedance control for Space Station Freedom operations. *Proceedings of the '91 International Conference on Intelligent Teleoperation*, Greensboro, NC. November 6–7, 1991. pp. 116–142. NRC 33160.

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- **Parent, A.** Analysis of dialogue protocols. *Proceedings of the 4th University of New Brunswick Artificial Intelligence Symposium*, Fredericton, N.B. September 19–21, 1991. pp. 295–305. NRC 33149.

- **Petriu, E., Greenspan, M.A., McMath, W.S., and Yeung, S.S.K.** Active tactile perception of 3D geometric profiles. *Proceedings of the IEEE IMTC/91 Instrumentation and Measurement Technology Conference*, Atlanta, GA. 1991. pp. 464–467

- **Podgorski, A.S.** Three-dimensional time domain model of lightning including corona effects. *Proceedings of the International Aerospace and Ground Conference on Lightning and Static Electricity*, Cocoa Beach, FL. April 16–17, 1991. pp. 75.1–75.7. NRC 31801.

- **Podgorski, A.S., and Campagna, P.** Low probability lightning threat. *Proceedings of EMC Technology EXPO-91 Symposium*, Orlando, FL. June 25–27, 1991. pp. A4.1–A4.5. NRC 31815.

- **Podgorski, A.S., Dunn, J., and Yeo, R.** Study of picosecond risetime in human-generated ESD. *IEEE International Symposium on Electromagnetic Compatibility Symposium Record*, Cherry Hill, NJ. August 12–16, 1991. pp. 263–264. NRC 31802.

- **Rioux, M., Beraldin, J.A., O'Sullivan, M., and Cournoyer, L.** Eye-safe scanner for range imaging. *Appl. Opt.* 30(16): 2219–2223; 1991. NRC 31800.

- **Robertson, W.M., Arjavalingam, G., Hougham, G., Kopcsay, G.V., Edelstein, D., Ree, M-H., and Chapple-Sokol, J.D.** Optoelectronic measurement of the broadband microwave dielectric properties of polymer films. *Proceedings of the 2nd IEEE International Workshop on Photonic Networks Components and Applications, "Photonics 92,"* Montebello, P.Q. March 9–11, 1992. Edited by J. Chrostowski and J. Terry. OCRI Publications 1992, Ottawa, Ont. pp. 3.2.1–3.2.5.

- **Roth, G., and Levine, M.D.** Random sampling for pose determination and refinement. *Proceedings of Vision Interface '91*, Calgary, Alta. June 3–7, 1991. pp. 104–111. NRC 33173.

- **Roth, G., and Levine, M.D.** A genetic algorithm for primitive extraction. *Proceedings of the Fourth International Conference on Genetic Algorithms*, San Diego, CA. July 13–16, 1991. pp. 487–494. NRC 33174.

- **Roth, G., and Levine, M.D.** Robustness in primitive extraction and correspondence computation. *Proceedings of SPIE Conference 1611, Sensor Fusion IV*, Boston, MA. November 13–15, 1991. pp. 542–554. NRC 33175.

- **Shimura, T., Boothroyd, S.A., Chrostowski, J., and Myslinski, P.** Picosecond pulse beam coupling in GaP for all optical routing. *Proceedings of the 2nd IEEE International Workshop on Photonic Networks Components and Applications, "Photonics 92,"* Montebello, P.Q. March 9–11, 1992. Edited by J. Chrostowski and J. Terry. CCRI Publications 1992, Ottawa, Ont. pp. 3.11.1–3.11.6. NRC 33194.

- **Soznowski, Z.A.** A prototype fuzzy expert system shell. *Proceedings of the Third Joint IFSA-EC and EURO-WG Workshop on Fuzzy Sets*, Visegrad, Hungary. December 11–13, 1990. In *Annales. Univ. Sci. Budapest, Sect. Comp.* 12: 225–229; 1991. NRC 31799.

- **Soznowski, Z.A.** A fuzzy extension of CLIPS rule-based shell. *Proceedings of the International Fuzzy Engineering Symposium '91*, Yokohama, Japan. November 13–15, 1991. In *Fuzzy Engineering Toward Human Friendly Systems*, Vol. 1, 1991. pp. 503–512. NRC 33145.

- **Soznowski, Z.A.** Data structures for representing and processing of fuzzy information in LISP. *Comput. Artif. Intell.* 10(6): 561–571; 1991. NRC 33158.

- **Sturgeon, R.E., Willie, S.N., Luong, V.T., and Dunn, J.G.** Influence of the generator frequency on the analytical characteristics of FAPES. *Appl. Spectrosc.* 45(9): 1413–1418; 1991. NRC 32922.

- **Turney, P.** Controlling super-intelligent machines. *Can. Artif. Intell.* 27: 3–4, 12, 35; 1991.

- **Turney, P.** The gap between abstract and concrete results in machine learning. *J. Exp. Theor. Artif. Intell.* 3: 179–190; 1991. NRC 31788.

- **Venkatesan, S., and Archibald, C.** Use of wrist mounted range profile scanners for real-time tracking. *Mach. Vision Appl.* 5: 1–16; 1992. NRC 33164.

- **Wein, M., Cowan, W., and Gentleman, W.M.** Visual support for version management. *Proceedings of the Symposium on Applied Computing (SAC) '92*, Kansas City, MO. March 1–3, 1992. pp. 1217–1223. NRC 33170.

- **Yamamoto, M., Boulanger, P., Beraldin, J.-A., Rioux, M., and Domey, J.** Direct estimation of deformable motion parameters from range image sequence. *J. Data Process. Soc.* 32(10): 1129–1141; 1991. NRC 33226.

- **Yuen, S.F., Chrostowski, J., and Syrett, B.A.** Balanced ARROW Mach-Zehnder interferometer. *Proceedings of the Canadian Conference on Electrical and Computer Engineering*, Québec, Que. September 25–27, 1991. pp. 52.2.1–52.2.3. NRC 33144.

- **Yuen, S.F., Chrostowski, J., and Syrett, B.A.** Organic polymer phase modulator. *Optical Society of America Annual Meeting Technical Digest Series*, 1991. Vol. 17, p. 43. NRC 33163. (Summary.).

Annex III. Awards and Distinctions

IIT's research program in 3-D vision, led by Marc Rioux, has achieved international recognition and continues to win prizes, most recently the first prize award for new media technology at Production 91. The Institute's world-class sensor, based upon a synchronized laser scanning technique, serves as the base for advanced vision technology applicable to such diverse tasks as the production of medical prostheses, preservation of museum artifacts and a wide variety of advanced manufacturing tasks.

Three staff members, J. Farlette, D. Kotak, and M. Scriabin, of the Systems Laboratory, were awarded first prize in the Competition on the Practice of Operational Research held at the Canadian Operational Research Society's Conference at the Chateau Frontenac in Québec. The prize was for their paper "Airport Capacity Planning Symbiotic System (AIRSYM): Combining Human and Artificial Intelligence" which was based on the joint project on Vancouver International Airport undertaken with Transport Canada and the Transportation Development Centre.

NRC Merit Award: Jeanne Chagnon

NRC Merit Award: Marc Rioux, François Blais, Jean-Angelo Beraldin, and Luc Cournoyer

The National Research Council has recently created a Merit Award program, which recognizes outstanding work performance or other meritorious contributions that have brought credit to NRC. At the first presentations, in 1991, Marc Rioux, François Blais, Jean-Angelo Beraldin, and Luc Cournoyer, of the Autonomous Systems Laboratory received a group award, and Jeanne Chagnon, Administrative Services, received an individual award.

Annex IV. Patents and Licences

Licence royalties received by the Institute for Information Technology in 1991–1992 totalled approximately $36 500. This was a decrease from the previous year. Since royalty payments are, for the most part, tied to sales of licensed products, this decrease is presumably related to the difficult economic climate world-wide. Preliminary reports for 1992–1993 suggest that royalties will be significantly greater than in 1991–1992.

New in 1991–1992

- **Autonomous Systems Laboratory.** High-speed laser range 3-D camera. Licensee: Hymarc Ltd. Signed January 13, 1992.
- **Beraldin, J.A., and Blais, F.** Method and system for increasing the effective dynamic range of a photosensor. U.S. Patent No. 4,967,066. Issued October 30, 1990. Can. Patent No. 1,298,380. Issued March 31, 1992. NRC 31791.
- **Blais, F.** Galvanometric optical scanning system. Can. Patent No. 1,295,039. Issued February 17, 1992. NRC 33190.
- **Boothroyd, S.A., and Chrostowski, J.** Interferometer. U.S. Patent No. 5,080,466. Issued January 14, 1992. NRC 33182.
- **Podgorski, A.S., and Gibson, G.** Gigahertz electromagnetic field simulator. Can. Patent. No. 2,047,999. Issued August 15, 1991. NRC 35026.
- **Rioux, M.** Three dimensional imaging device. U.S. Patent No. 5,018,854. Issued May 28, 1991. NRC 31834.
- **Rioux, M.** Three dimensional imaging device comprising a lens system for simultaneous measurement of a range of points on a target surface. U.S. Patent No. 5,075,561. Issued December 24, 1991. NRC 33180.

Continuing

- **Blais, F.** Peak position detector. U.S. Patent No. 4,658,368. Issued April 4, 1987. Can. Patent No. 1,253,581. Issued May 2, 1989. NRC 31674.
- **Blais, F.** Galvanometric optical scanning system having a pair of closely located synchronization. U.S. Patent No. 4,800,270. Issued January 24, 1989. NRC 31675.
- **Blais, F.** Galvanometric optical scanning system having synchronization photodetectors. U.S. Patent No. 4,800,271. Issued January 24, 1989.
- **Blais, F.** Peak detector and imaging system. U.S. Patent No. 4,819,197. Issued April 4, 1989.
- **Boothroyd, S.A., Chrostowski, J., and O'Sullivan, M.S.** Optical phase to amplitude demodulation. U.S. Patent No. 4,983,024. Issued January 8, 1991. NRC 31796.
- **Bouchard, C., and Boulanger, P.** Particle detector. U.S. Patent No. 4,680,468, July 14, 1987. Can. Patent No. 1,240,075. August 2, 1988.
- **Chrostowski, J., and Bock, W.** Method and leadthrough system for laying out optical fibres across an aperture of a container shell. U.S. Patent No. 4,883,336. Issued November 28, 1989. NRC 31423.
- **Domey, J., and Rioux, M.** Non-contact optical apparatus for measuring the length or speed of a relatively moving surface. U.S. Patent No. 4,334,779. Issued June 15, 1982. Can. Patent No. 1,146,242. Issued May 10, 1983.
- **Forester, G.V., Mortimer, A.J., and Roy, O.Z.** Method and device for enhancement of cardiac contractility synchronised with ECG event or defibrillation pulse. Can. Patent No. 1,199,371. Issued January 14, 1986. U.S. Patent No. 4,651,716. Issued March 24, 1987.
- **Hlady, A.** Touch sensitive position encoder using a layered sheet. Japan Patent No. 991,709. Issued March 27, 1980.
- **Kashyap, S.C., and Wyslouzil, W.** Control system for non-resonant microwave dryers. U.S. Patent 4,035,599. Issued July 12, 1977. Can. Patent No. 1,032,616. Issued June 6, 1978.
- **Kashyap, S.C., and Wyslouzil, W.** Single-sided microwave applicator for sealing cartons. U.S. Patent No. 4,160,144. Issued July 3, 1979.
- **Kashyap, S.C., and Wyslouzil, W.** Single-sided applicator for microwave heating. Can. Patent No. 1,167,531. Issued May 15, 1984.
- **Kashyap, S., Dunn, J.G., Woods, L., and Vachon, F.** Microwave apparatus for heating liquid in a closed plastic container. U.S. Patent No. 4,336,435. Issued June 22, 1982. Can. Patent No. 1,170,313. Issued July 3, 1984.
- **Korba, L.W.** Computer speed control. Can. Patent No. 1,216,071. Issued December 30, 1986. U.S. Patent No. 4,631,702. Issued December 23, 1986.
- **Podgorski, A.S.** Wide band electric field sensor. Canadian Know-how Licence. Granted March 21, 1984.
- **Rioux, M.** Three dimensional imaging device. U.S. Patent. No. 4,645,347. Issued April 1987. Can. Patent No. 1,272,406. Issued August 7, 1990.
- **Rioux, M.** Synchronous optical scanning apparatus. U.S. Patent 4,787,748. Issued November 29, 1988.
- **Rioux, M.** Three dimensional imaging method and device. U.S. Patent No. 4,627,734. Issued

December 6, 1986. Can. Patent No. 1,245,889. Issued December 5, 1988.

- **Software Engineering Laboratory**. Harmony real-time operating system. Licensee: Precise Software Technologies Inc. Signed January 30, 1991.
- **Systems Laboratory.** Audition (MS-DOS Extended Memory version). Licensee: Synaptec Holdings Ltd. Signed August 29, 1990.
- **Wong, J.Y., Kashyap, S.C., and Dunn, J.G.** Microwave leakage indicator strip. U.S. Patent No. 4,065,655. Issued December 27, 1977. Can. Patent No. 1,069,185. Issued January 1, 1980.
- **Wyslouzil, W., and Kashyap, S.C.** Microwave applicator for frozen ground. U.S. Patent No. 4,571,473. Issued February 18, 1986. Can. Patent No. 1,207,843. Issued July 15, 1986.
- **Wyslouzil, W., and Kashyap, S.C.** Apparatus for heating granular materials. Can. Patent No. 1,234,877. Issued April 5, 1988.

Annex V. Presentations

- **Archibald, C.** Sensor-based robot programming by combining simple skills. Colloquium Series, University of Alberta, Edmonton, Alta. February 10, 1992.
- **Barnard, C., Kavehrad, M., and Chrostowski, J.** Designing fiber amplifiers for photonic distribution networks. Thrust Interaction Group Meeting, Telecommunications Research Institute of Ontario (TRIO), Communications Research Centre, Ottawa, Ont. November 22, 1991.
- **Blais, F.** Développement de capteurs de mesure de distance au CNRC. Institut National d'Optique, Ste-Foy, Que. June 10, 1991.
- **Boothroyd, S.** Nonlinear optics and phase conjugation. Department of Physics, Dalhousie University, Halifax, N.S. April 10, 1991.
- **Boothroyd, S.** Nonlinear optics and phase conjugation. Department of Physics, University of Sherbrooke, Sherbrooke, Que. November 28, 1991.
- **Brahan, J.** Research and development in artificial intelligence at NRC. Graduate Seminar, Computer-based Learning Unit, University of Leeds, Leeds, U.K. December 6, 1991.
- **Chan, A.** Industrial application of information technology in the development of decision support systems. Artificial Intelligence, Industrial Application Conference, Thunder Bay, Ont. March 26–27, 1992.
- **Chan, A., and Nenonen, L.** Object oriented modelling technology for use with expert systems: a pulp inventory control example. Pulp and Paper Expert Systems Workshop, Pointe Claire, Que. November 14, 1991.
- **Chan, S.** Geometric modelling and CAD/CAM applications. École Polytechnique, Montreal, Que. October 2, 1991.
- **Chrostowski, J.** Adaptive optical processing for 3D vision. New Information Processing Technologies (NIPT) Workshop '91, Yokohama, Japan. November 5–8, 1991.
- **Chrostowski, J.** Optical processing at NRC. Optical Processing Section Seminar, Electrotechnical Laboratory, Tsukuba, Japan. November 12, 1991.
- **Chrostowski, J.** Optical computing: a global perspective. IEEE Symposium "Photonics 2001," Halifax, N.S. February 19, 1992. (Invited.).
- **Domey, J., and Godin, G.** 3D vision and robotics research at the National Research Council of Canada. Electrotechnical Laboratory, Tsukuba, Japan. March 3, 1992.
- **Famili, A.** Applications of machine learning in industrial automation. 8th International Machine Learning Workshop, Evanston, IL. June 27–29, 1991.
- **Gentleman, W.M.** Debugging and program paradigms for embedded systems. Ottawa Carleton Research Institute, Trends in Real-time Software Engineering, Ottawa, Ont. October 10, 1991.
- **Gentleman, W.M.** Portability in the 90s. USENIX Winter 1992 Technical Conference, San Francisco, CA. January 20–24, 1992. (Invited.).
- **Gentleman, W.M., Gauthier, C., Gentleman, W.M., and Wein, M.** Harmony: a realtime object-based solution. OOPSLA/ECOOP '90 Workshop: Using OOP for realtime programming, Ottawa, Ont. October 21, 1990.
- **Halasz, M.** Engine diagnostic support systems. The 5th Master Data Exchange Agreement Meeting, Arnold Air Force Base, Tullahoma, TN. June 12, 1991.
- **Henneker, W.H.** The role of intelligent user interfaces as an aid to decision making. The Canadian Operational Research Society Conference, Operational Research and Information Technology, Québec, Que. May 21–23, 1991.
- **Huang, X.** Updating belief systems: minimal change, focus of attention, and stereotypes. NRC/IIT Colloquium Series, March 10, 1992.
- **Korba, L.W.** Hardware issues for rehabilitation robotics. 2nd International Conference on Rehabilitation Robotics, Atlanta, GA. June 19–20, 1991. (Invited.).
- **Korba, L.W.** On being inventive. Collège Catholique Samuel-Genest, Ottawa, Ont. October 1, 1991. (Invited.).
- **Korba, L.W., Harwin, W., and Dargie, G.** Safety and liability issues in rehabilitation robotics. Seminar, 14th Annual Conference of the Rehabilitation Engineering Society of North America, Kansas City, MO. June 21–26, 1991.
- **Korba, L.W., Harwin, W., and Dargie, G.** Safety and liability issues in rehabilitation robotics. Open Forum, 14th Annual Conference of the Rehabilitation Engineering Society of North America, Kansas City, MO. June 21–26, 1991.
- **Liscano, R.** Collision avoidance methods for a mobile robot. PAMI Group Seminar, University of Waterloo, Waterloo, Ont. September 30, 1991.
- **MacKay, S.** The Harmony realtime operating system project. School of Computer Science, Acadia University, Wolfville, N.S. April 1, 1991.
- **MacKay, S.** The Harmony realtime operating system project. Faculty of Computer Science, University of New Brunswick, Fredericton, N.B. April 3, 1991.
- **Myslinski, P.** Q-switched erbium doped fiber laser. National Research Council, Ottawa, Ont. March 6, 1991.

- **Myslinski, P.** Q-switched erbium doped fiber laser. Lumonics, Kanata, Ont. August 21, 1991.
- **Myslinski, P., Chrostowski, J., Koningstein, J.A., and Simpson, J.R.** Eye-safe lasers for ranging applications. Ottawa Carleton Research Institute Workshop "Challenges of Medical Engineering," Ottawa, Ont. June 4, 1991.
- **Neelamkavil, J., and Chan, A.** Application of information technology to industrial scheduling. NRC Industrial Engineering Forum, Montreal, Que. November 13–15, 1991.
- **Podgorski, A.S., and Campagna, P.** Report on a new wide-band HERO testing method. U.S. Navy Electromagnetic Effects Working Group Meeting, Washington, DC. November 4–8, 1991.
- **Rioux, M.** Technology and applications of digital 3D imaging, Artificial Intelligence Laboratory, University of Toronto, Toronto, Ont. May 8, 1991.
- **Roth, G.** Range image processing at NRC-IIT. Media Laboratory, Massachusetts Institute of Technology, Boston, MA. November 15, 1991.
- **Scriabin, M.** Symbiotic systems for production planning. American Society of Mechanical Engineering, Vancouver, B.C. March 28, 1991. (Invited.).
- **Scriabin, M.** Airport capacity planning symbiotic system. Canadian Operational Research Society, Vancouver, B.C. April 9, 1991. (Invited.).
- **Scriabin, M.** Airport capacity planning symbiotic system. Canadian Operational Research Society Conference, Québec, Que. May 22, 1991. (Invited.).
- **Scriabin, M.** The role of symbiotic systems in technology transfer. Camosun College, Victoria, B.C. June 11, 1991. (Invited.).
- **Scriabin, M.** Symbiotic systems: combining human and artificial intelligence. University of Victoria, Victoria, B.C. June 24, 1991. (Invited.).
- **Scriabin, M.** AIRSYM airport capacity planning symbiotic system. Abbotsford Airshow, Abbotsford, B.C. August 7–11, 1991.
- **Scriabin, M.** Combining ES, OOP, and human creativity. University of Victoria, Victoria, B.C. October 10, 1991. (Invited.).
- **Scriabin, M.** Symbiotic systems in hard problems. University of British Columbia, Vancouver, B.C. November 14, 1991. (Invited.).
- **Scriabin, M.** Supporting human creativity in problem solving. University of British Columbia, Vancouver, B.C. January 13, 1992. (Invited.).
- **Scriabin, M.** Combining human and artificial intelligence in hard problems. Softwords, Victoria, B.C. January 24, 1992. (Invited.).
- **Scriabin, M.** Supporting human creativity in problem solving. University of British Columbia, Vancouver, B.C. February 24, 1992. (Invited.).
- **Scriabin, M.** Symbiotic systemes and AI in large scale complex systems. University of Victoria, Victoria, B.C. March 18, 1992. (Invited.).
- **Syrett, B.A., Chrostowski, J., Yuen, S., Chan, L., and Peereboom, N.** Optical interconnects. Thrust Interaction Group Meeting, Telecommunications Research Institute of Ontario (TRIO), Communications Research Centre, Ottawa, Ont. November 22, 1991.
- **Turney, P.** Analysis of jet engine data to aid in diagnosis. The Technical Cooperation Program, Technical Panel HTP-7, Boca Raton, FL. June 10, 1991.
- **Turney, P.** Analysis of jet engine data to aid in diagnosis. The 5th Master Data Exchange Agreement Meeting, Arnold Air Force Base, Tullahoma, TN. June 12, 1991.
- **Turney, P.** Two phase learning for jet engine diagnosis. Computer Science Department, University of Ottawa, Ottawa, Ont. November 8, 1991.
- **Wein, M.** User interfaces for realtime systems. Information Technology Research Centre and Prior Data Sciences Workshop "Applied Human-Computer Interaction," Toronto, Ont. June 25, 1991.
- **Wein, M.** User interfaces for realtime systems. ACM/CHI Ottawa Chapter, Ottawa, Ont. July 9, 1991.

Annex VI. Participation on Committees

- **Archibald, C.** Organizing Committee, Vision Interface '91 Conference. Program co-chairman.
- **Archibald, C.** Program Committee, Vision Interface '92 Conference.
- **Brahan, J.W.** Program Committee, ITS '92 Second International Conference on Intelligent Tutoring Systems.
- **Brahan, J.W.** Organizing Committee, Seventh Canadian Symposium on Instructional Technology.
- **Brahan, J.W.** Organizing Committee, Sixth International Conference on Systems Research, Informatics and Cybernatics.
- **Brahan, J.W.** AI Symposium Program, Sixth International Conference on Systems Research, Informatics and Cybernatics. Chairman.
- **Burtnyk, N.** International Committee, International Advanced Robotics Programme.
- **Chan, A.W.** Industrial Engineering Grant Selection Committee, Natural Sciences and Engineering Research Council. Secretary.
- **Chan, S.** Technical Committee 184, Subcommittee 4, International Standards Organization. Canadian delegate.
- **Chrostowski, J.** Lasers and Electro-Optics Society, Ottawa Chapter, Executive Committee, Institute of Electrical and Electronics Engineers. Chairman.
- **Chrostowski, J.** Editorial Board, *Microwave and Optical Technology Letters*, John Wiley & Sons, Inc.
- **Chrostowski, J.** Editorial Board, *Optics Communications*, Elsevier Science Publishers.
- **Chrostowski, J.** Organizing Committee, Second IEEE International Workshop on Photonic Networks, Components and Applications. Technical Program Chairman.
- **Chrostowski, J.** Organizing Committee, IEEE International Workshop on Photonic Networks, Components and Applications. Proceedings Editor.
- **Chrostowski, J.** Executive Committee, Ottawa Section, Institute of Electrical and Electronics Engineers. Vice-Chairman.
- **Chrostowski, J.** Comité scientifique, Colloque Optique Guidée et Photonique II.
- **Collins, M.M.C.** Research and Development Management Board, Canadian Electrical Association.
- **Collins, M.M.C.** Industrial Chair Site Visit Committee (University of Manitoba), Natural Sciences and Engineering Research Council.
- **Collins, M.M.C.** Hydro Study Panel and Chief Operating Committee "EMF Study in Carleton Board Schools," Carleton Board of Education.
- **Collins, M.M.C.** Scientific Review Panel for "60 Hz EMF Animal Carcinogenesis Study," Health and Welfare Canada, Hydro Quebec.
- **Collins, M.M.C.** Technical Advisory Committee, CEA Project 272T732, "Epidemiological Study of Cancer and Exposure to Power Frequency Electric and Magnetic Fields," Canadian Electrical Association. Chairman.
- **Collins, M.M.C.** STEAR Program Evaluation Steering Committee, Canadian Space Agency.
- **Domey, J.** Technical Committee on Components and Instrumentation, International Federation of Automatic Control.
- **Domey, J.** Editorial Board, *Industrial Metrology*, Elsevier Science Publishers.
- **Elgazzar, S.** National Advisory Committee on Mining Automation.
- **Elgazzar, S.** Canadian Advisory Committee on Technical Committee 184, Subcommittee 2, Standards Council of Canada. Chairman.
- **Famili, A.** Editorial Board, *The International Journal of Advanced Manufacturing Technology*, Published by Springer International, London.
- **Famili, A.** Editorial Board, *Journal of Production, Planning and Control*, Taylor and Francis, London.
- **Famili, A.** Program Committee, International Conference of Object-oriented Manufacturing Systems (ICOOMS '92).
- **Farley, B.** Canadian Government Keyboard Standard Working Group, Treasury Board.
- **Forester, G.V.** Editorial board, *Ultrasound in Medicine and Biology*, Pergamon Press.
- **Forester, G.V.** External Scientific Review Committee, Electrohydraulic Ventricular Assist Device. Chairman.
- **Forester, G.V.** Scientific Review Committee, Premier's Technology Fund, Government of Ontario.
- **Gentleman, W.M.** Working Group 2.5, Numerical Software, International Federation for Information Processing.
- **Gentleman, W.M.** Editorial Board, *The Computer Journal*, The British Computer Society.
- **Gentleman, W.M.** Technical Study Group 1, Interfaces for Application Portability, International Standards Organization/International Electrotechnical Commission, Joint Technical Committee. Delegate.
- **Gentleman, W.M.** Canadian Special Working Group on Application Portability, Canadian Standards Association. Chairman.
- **Gentleman, W.M.** Strategic Grant Selection Panel for Information Systems, Natural Sciences and Engineering Research Council.

- **Gentleman, W.M.** Editorial Board, *Concurrency Practice and Experience*, John Wiley & Sons, Inc.
- **Graefe, P.W.U.** Canadian Advisory Committee for the International Standards Organization, Technical Committee 184, Standards Council of Canada.
- **Graefe, P.W.U.** Technical Committee 184, Subcommittee 5, Working Group 4, International Standards Organization. Convener.
- **Graefe, P.W.U.** International Program Committee, Information Control Problems in Manufacturing Technology. Chairman.
- **Graefe, P.W.U.** International Program Committee, IFAC Workshop on Intelligent Manufacturing Systems.
- **Graefe, P.W.U.** Canadian Advisory Committee for the International Standards Organization, Technical Committee 184, Standards Council of Canada. Chairman.
- **Henneker, W.** Grant Selection Committee for Computing and Information Science, Natural Sciences and Engineering Research Council. Secretary.
- **Henneker, W.H.** Steering Committee on Information Technology, Canadian Standards Association.
- **Kashyap, S.** Canadian Subcommittee of the International Electrotechnical Commission on Waveguides and Accessories, Canadian National Committee of the International Electrotechnical Commission: Standards Council of Canada. Chairman.
- **Kashyap, S.** Technical Committee on Electromagnetic Compatibility Measurement Methods, Canadian Standards Association. Vice-chairman.
- **Kashyap, S.** Technical Committee on Electromagnetic Compatibility of Radio Frequency Generators, Canadian Standards Association.
- **Liscano, R.** Program Committee, IEEE International Symposium on Intelligent Control.
- **MacKay, S.A.** Organizing Committee, Graphics Interface '91 Conference. Proceedings Editor.
- **Mayman, S.A.** Board of Advisors, Canadian Manufacturing Advanced Technology Exchange, Canadian Manufacturers' Association.
- **Mayman, S.A.** Advisory Committee for Natural Sciences and Engineering Research Council NSERC Industrial Research Chair in Applied Electromagnetics, University of Manitoba. Chairman.
- **Mayman, S.A.** AI R&D Fund Advisory Committee, Industry, Science and Technology Canada.
- **Mayman, S.A.** Communications Technologies Research Advisory Board, Department of Communications.
- **Mayman, S.A.** IT Sector Round Table, Industry, Science and Technology Canada.
- **Mayman, S.A.** Board of Directors, PRECARN Associates
- **Mayman, S.A.** Policy and Planning Committee, PRECARN Associates.
- **O'Hara, D.H.** Advisory Board for RFP#3, Canadian Space Agency.
- **Podgorski, A.S.** Technical Committee on EMC of HV Systems, Canadian Standards Association.
- **Podgorski, A.S.** Canadian National Subcommittee of the International Electrotechnical Commission, Special Committee on Radio Interference, Standards Council of Canada.
- **Podgorski, A.S.** Steering Committee on EMC, Canadian Standards Association.
- **Podgorski, A.S.** High Voltage Testing Techniques Subcommittee, Institute of Electrical and Electronic Engineers.
- **Rioux, M.** Editorial Board, *Optics and Lasers in Engineering*, Elsevier Applied Science.
- **Thomson, V.** Canadian Advisory Committee for the International Standards Organization, Technical Committee 184, "Industrial Automation Systems and Integration," Standards Council of Canada.
- **Thomson, V.** Technical Committee 184, Subcommittee 5, "Architecture and Communication," International Standards Organization.
- **Thomson, V.** Technical Committee 184, Subcommittee 5, Working Group 1, International Standards Organization.
- **Thomson, V.** Advisory Committee on Industrial Manufacturing Systems, Industry, Science and Technology Canada.
- **Thomson, V.** Europe 1992 Technical Cooperation Subgroup, Working Group on Telecommunications and Informatics, Department of Communications, External Affairs and International Trade Canada.
- **Wein, M.** Software Systems and Graphics Area Committee, Information Technology Research Centre, Ontario Centres of Excellence.
- **Wein, M.** Awards Committee, "The Steven A. Coons Awards," Association for Computing Machinery, Special Interest Group in Computer Graphics.

Adjunct Appointments

- **Chrostowski, J.** Department of Electrical Engineering, University of Ottawa.
- **Chrostowski, J.** Department of Electrical and Computer Engineering, University of Waterloo.
- **Podgorski, A.S.** Department of Electrical Engineering, University of Ottawa.
- **Scriabin, M.** Faculty of Commerce and Business Administration, University of British Columbia.
- **Wein, M.** Department of Computer Science, University of Waterloo.

Annex VII. List of Employees

Director General — S.A. Mayman
Director, Software Technology — M.M.C. Collins
Director, Systems Technology — V.J. Thomson

Autonomous Systems Laboratory — J. Domey

Scientific Staff

Archibald, C.
Beraldin, J.-A.
Blais, F.
Boulanger, P.B.
Brooks, M.
Burtnyk, N.
Chrostowski, J.
Couvillon, R.
Elgazzar, S.
Godin, G.
Green, D.A.
Korba, L.W.
Lang, S.
Liscano, R.
Rioux, M.
Robertson, W.
Roth, G.K.
Zhang, F.

Support Staff

Cournoyer, L.
Dufour, A.G.
Gariépy, P.
Misner, R.
Park, G.C.
Taylor, D.G.

Summit Post-Doctoral Fellow

Shimura, T.

Research Associates

Myslinski, P.
Palacharla, P.

Guest Workers

Bacaer, P.
University of Ottawa
Baribeau, R.
Canadian Conservation Institute
Barnard, C.W.
University of Ottawa
Basran, J.S.
University of Ottawa
Boothroyd, S.
University of Ottawa
Bouanane, B.
Castonguay, A.
Carleton University
Chan, L.
Carleton University
Fayek, R.E.
Carleton University
Hill, G.
Hymarc Limited
Ibrahim, N.E.M.
Minia University, Egypt
Kalaycioglu, S.
Thomson-CSF Systems of Canada
Knabke, G.
University of Ottawa
MacDonald, R.
Carleton University
Morgera, S.
McGill University
Petriu, E.
University of Ottawa
Rail, A.
Adult High School, Ottawa
Schinn, G.
MPB Technologies, Inc.
Seifu, S.
Thomson-CSF Systems of Canada
Sellars, J.
Carleton University
Simkin, D.
McGill University
Syrett, B.
Carleton University
Tandirci, M.
Thomson-CSF Systems of Canada
Venkatesan, S.
Concordia University
Yaremchuk, G.
Nepitek
Yuen, S.
Carleton University
Zaccarin, D.
University of Ottawa

Temporary Assistants

Beckwith, P.
Gauthier, M.
Greenspan, M.
Lecavalier, M.
Manz, A.

Knowledge Systems Laboratory — J.W. Brahan

Scientific Staff

Abu-Hakima, S.
Diaz, A.
Famili, A.
Farley, B.
Halasz, M.S.
Henneker, W.H.
Orchard, R.A.
Parent, A.
Phan, C.S.
Wylie, R.H.

Support Staff

Born, R.V.
Orpana, F.P.
Shevel, R.

Post-Doctoral Fellows

Turney, P.D.
Huang, X.

Guest Workers

Davidson, P.L.
Former NRC Staff
Taylor, T.
Phalanx Research Systems

Software Engineering Laboratory — W.M. Gentleman

Scientific Staff

Gauthier, C.
Kark, A.
MacKay, S.A.
Stewart, D.A.
Wein, M.

Support Staff

Binch, A.
Duggan, M.D.

Guest Workers

Allen, I.
University of Waterloo
Krieger, M.
University of Ottawa
Wong, V.
Colonel By High School, Gloucester

Systems Integration Laboratory — P.W.U. Graefe

Scientific Staff

Amyot, R.
Atabakhsh, H.
Chan, A.W.
Kashyap, S.
Kekez, M.M.
Lovetri, J.
Resigned June 1991
Neelamkavil, J.D.
Nenonen, L.K.
Pardasani, A.
Podgorski, A.S.
Seregelyi, J.

Support Staff

Brauen, G.
Resigned November 1991
Cook, P.R.
Dunn, J.G.
Chan, S.
Gibson, G.
Leung, Y.
Resigned September 1991

Guest Workers

Abboud, R.
Interfacing Technologies Corp.
Cloutier, N.
EDS Canada
Cook, D.
EDS Canada
Hendry, A.
Retired NRC staff member
Levi, M.
Interfacing Technologies Corp.
Rix, S.
Phoenix Systems Synetics, 1991

Tyrie, R.
Phoenix Systems Synetics, 1991
Zhao, X.
Water Transportation Institute, China

Temporary Assistant

Ah-Hee, S.
Corrin, D.

Systems Laboratory — D.B. Kotak

Scientific Staff

Scriabin, M.
Swinkels, G.
Resigned September 1991
Whale, K.

Support Staff

Farlette, J.
Mulder, L.
Resigned August 1991
Tamoto, H.

Research Associate

Guan, Y.

Guest Workers

Matkowski, Z.D.H.
King, Matkowski & Associates

Temporary Assistants

Drinnan, A.
Elliot, J.
Resigned February 1992
Morton, D.
Sahota, N.

Industrial Liaison Office — A.M. Hlady

Durie, N.D.
Retired March 1992
Forester, G.V.
O'Hara, D.H.

Administrative Services — M.M. Fox

Bedard, M.
Chagnon, J.
Chartrand-Mulvey, L.
Charlebois, C.
Colwell, M.
Grundy, D.
On secondment from Hertzberg Institute of Astrophysics
Hopson, E.
Houle, C.
Kidd, E.M.
Lamont, J.D.
Manson, M.
Osborn, L.
Rawes, K.
Tierney, T.A.
Wilson, D.G.D.
Transferred to Informatics April 1991

Temporary Assistants

Branchaud, R.M.
Oickle, R.M.
Toth, C.
Resigned March 1992

Technical Services — C.C. Eamer

Amirault, P.C.
Bouchard, S.
Bramall, B.K.
Cameron, L.A.
Curry, D.
Dunlop, D.A.
Farr, B.C.
Gamache, D.
Hendley, J.G.
Lajeunesse, M.
Schoenherr, K.
Taylor, A.R.
Tierney, K.G.
Valliéres, R.
Resigned September 1991
Walker, G.D.

Guest Worker

Poulin, D.A.W.
Retired NRC staff

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